UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

LBP-05-29

ATOMIC SAFETY AND LICENSING BOARD
Before Administrative Judges:

DOCKETED AND SERVED 10/28/05

Michael C. Farrar, Chairman
Dr. Peter S. Lam
Dr. Paul B. Abramson

In the Matter of	Docket No. 72-22-ISFSI
PRIVATE FUEL STORAGE, LLC	ASLBP No. 97-732-02-ISFSI
(Independent Spent Fuel Storage Installation)	October 28, 2005

ORDER ISSUING REDACTED VERSION
OF FINAL PARTIAL INITIAL DECISION

Our Final Partial Initial Decision in this proceeding, resolving the accidental aircraft crash "consequences" issue, was originally issued on February 24 of this year. Because our discussion therein involved Safeguards-protected matters, that decision was issued in two formats: one available to the public, and the other (the "official" one) available only to the litigating parties and to any reviewing tribunals. The publicly-available version differed from the non-public version in that the public Part II contained only a 13-page non-Safeguards summary or paraphrase of the Board majority's reasoning on the crucial issues, rather than the full technical analysis, including Safeguards information, detailed in the 43 pages of the non-public version of Part II. All other portions of the two versions, including the dissent, were identical.

We indicated at that time (see Feb. 24 cover Memorandum, p. 2; Decision, p. C-6) that we were retaining jurisdiction to attempt to issue later a redacted decision that would make as much of our reasoning, other than its Safeguards aspects, available to the public. Following issuance of the Commission's final decision on the matter (CLI-05-19, 62 NRC ___(Sept. 9,

2005)), the parties agreed on the Safeguards redactions (involving all or part of only some 34 lines) necessary to allow our earlier Decision to be released publicly. The Board's own NRC Safeguards expert, who had advised us as to those aspects of our earlier decisions, concurred.

Accordingly, the redacted Decision attached hereto, consisting of (1) the previously publicly-available portions -- i.e., the opening "Overview and Summary;" the Part I "Procedural and Substantive Background;" the Part III "Conclusions of Law and Conclusion of the Proceeding;" the dissent; and the Appendix[1] -- and (2) the newly-available Safeguards-redacted 43-page Part II "The Merits," [2] will be PUBLISHED physically, under this date and preceded by this Order, in the bound volumes of the periodic Nuclear Regulatory Commission Issuances.[3] The redacted Decision will also be PROVIDED electronically in the agency's ADAMS system for public viewing and reference.

The Decision may be cited as "LBP-05-29, 62 NRC ___ (February 24 [as redacted October 28], 2005)." The previously-issued unofficial, public version of our Decision, with its

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[1] In re-issuing those portions, we have (1) made minor, non-substantive typographical or syntactical corrections thereto; and (2) conformed the description therein of the handling of the different versions of Part II to the present circumstances.

[2] The now-available redacted Part II is essentially identical to the original Safeguards-protected Part II, except for (1) some unavoidable minor, non-cumulative changes in page or line breaks; (2) the redactions themselves, as indicated by a series of XXXXX's occupying approximately the same typographical space as the text removed; (3) the change of several incorrect "Section A" references to refer instead to "Part I"; (4) the correction in footnote 125 of the "note 75" reference to refer instead to "note 124"; and (5) typographical corrections.

[3] In this regard, because it did not contain Safeguards information, our May 24 decision on reconsideration has already been published (see LBP-05-12, 61 NRC 319). As noted in the text (p. 1, above), the Commission's September 9 final decision on the matter is likewise being published.

13-page non-Safeguards paraphrase or summary of Part II, will remain available on ADAMS for reference purposes (accession # ML050620391). [4]

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[4] Owing to the nature of a characterization contained therein, the Board finds it appropriate to comment upon an aspect of the NRC Staff's September 28, 2005 "Motion for Directed Certification and Stay of the Licensing Board's [September 15] 'Order Regarding Redaction of Final Partial Initial Decision.'" Therein, the Staff argued to the Commission, inter alia, that (1) the Board lacked authority to conduct redaction; (2) the Board had created a "balancing" test that could compromise the protection of Safeguards information, and the nation's common defense and security, in favor of the public's interest in viewing aspects of our decision; and (3) the redaction process would be so complex as to cause substantial further delay in the proceeding.

As to ground # 3 above, the redaction process proved simple and rapid, leading the Commission to dismiss the Staff's pleading as moot. CLI-05-22, 62 NRC ___ (Oct. 19, 2005). As is customary, the Commission went on therein to vacate our redaction order (to eliminate "any confusion or future effects stemming from unreviewed Board decisions"), while recognizing that our redacted decision was "now ready for publication." 62 NRC at ___ (slip op. at 3).

The matter could rest there but for the Staff characterization of the Board's action reflected in ground # 2, above, which could lead to a misunderstanding about the Board's intentions in terms of protecting Safeguards information. So that the record is clear as to what we actually did, we simply note that, in facing the possible need to determine what redactions should be made (as the Commission has now confirmed we should do with the assistance of our appointed adjudicatory employee (62 NRC at ___, slip op. at 4; compare p. 2, above)), we never considered that we should -- and cannot fathom what in the record led the Staff to believe that we might -- "balance" the protection of Safeguards information, and of national security interests, against the opportunity for the public to see more of our reasoning. See Sept. 28 Staff Motion at, e.g., 3. We neither used the word nor envisioned the concept. Indeed, we said essentially the opposite: see Sept. 15 Order, p. 4, urging "the parties" not to "over-reach" regarding their respective positions, for while "on the one hand, security interests will demand that certain material be protected, . . . excessive protection will deprive the citizens of Utah and the nation of the opportunity to understand more fully what underlies the agency's decision on this important issue" (emphasis added). The point is this: a desire to avoid excessive protection does not equate to, or include the suggestion of, a willingness to trade required protection for other values.

For litigants' future guidance on a related point, we remind them that, as far as we know, when disputes have arisen as to the extent of disclosure of material claimed to be protected, all previous Boards have done as we would have done here, that is, stayed, on the Board's own volition, the actual release of any contested document pending Commission review of any Board ruling that rejects a withholding claim. Requests for extraordinary remedies would not, then, be expected to be required in order for a party to protect its interest in non-disclosure.

It is so ORDERED.

THE ATOMIC SAFETY
AND LICENSING BOARD

/RA/

Michael C. Farrar, Chairman
ADMINISTRATIVE JUDGE

/RA/

Peter S. Lam
ADMINISTRATIVE JUDGE

Separate Opinion of Judge Abramson:

I concur in the issuance of the redacted Board decision and endorse the process adopted by the Board's Chairman in causing its preparation, but see no need for, or merit in, addressing in this Order the matters covered in footnote 4, and to that extent I dissent.

Rockville, Maryland
October 28, 2005

Copies of the foregoing documents were sent this date by Internet e-mail transmission to counsel for (1) Applicant PFS; (2) Intervenor State of Utah; and (3) the NRC Staff.

ATTACHMENT:

REDACTED VERSION FOR PUBLICATION

OF

LICENSING BOARD'S FEBRUARY 24, 2005

"FINAL PARTIAL INITIAL DECISION"

ON F-16 AIRCRAFT ACCIDENT CONSEQUENCES

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

LBP-05-29

ATOMIC SAFETY AND LICENSING BOARD
Before Administrative Judges:

Michael C. Farrar, Chairman
Dr. Peter S. Lam
Dr. Paul B. Abramson

In the Matter of	Docket No. 72-22-ISFSI
PRIVATE FUEL STORAGE, LLC	ASLBP No. 97-732-02-ISFSI
(Independent Spent Fuel Storage Installation)	February 24 (as redacted October 28), 2005

FINAL PARTIAL INITIAL DECISION --Redacted Version for Publication [1]
(Regarding F-16 Aircraft Accident Consequences)

Overview and Summary**.** Over the last several years, this Board has resolved a large number of wide-ranging issues regarding the application of a nuclear utility consortium known as Private Fuel Storage to construct and to operate -- on a Goshute Indian Reservation in Skull Valley, Utah, 50 miles southwest of Salt Lake City -- an aboveground facility for the temporary storage of spent fuel from the nation's nuclear reactors. If created as planned, that facility would consist of an array of 500 concrete pads, each 67 feet by 30 feet, on which would sit 4,000 cylindrical storage casks, each nearly 20 feet in height and 11 feet in diameter. Each carbon-steel-encased concrete cask would hold a stainless steel canister housing spent fuel rods.

The only question remaining before us was raised by the State of Utah and concerns the risk to those casks and their contents presented by an accidental crash of one of the some 7,000 flights of F-16 military jets that head down Skull Valley each year. By a 2-1 vote (Judge Lam dissenting), we resolve that question in favor of the Applicant (whose position the NRC Staff supported). Issuance of the requested license is now for the Commission to consider (see

[1] Initially, two versions of this decision were issued: (1) the official one, which contained "Safeguards" information and thus could not be released to the public; and (2) an unofficial one, containing no Safeguards information and thus available to the public. The differences between their respective contents are explained herein and in the Public Version's cover Memorandum.

p. 8, below, n.14 and accompanying text). In the rest of this introduction, we provide a brief summary of the facts and an overview of the reasoning underlying our decision.[2]

1. Spent Fuel Logistics. Each of the 4,000 casks described above would be comprised of an "overpack" -- consisting in part of over two feet of concrete sandwiched between carbon steel shells (a 3/4-inch-thick outer shell, and an inner shell with attached liner totaling 2 inches) -- housing and protecting a 1/2-inch-thick stainless steel "multi-purpose canister" (MPC) resting inside it. The MPCs would have been loaded with spent nuclear fuel at different reactors around the country, welded shut, and moved to the site by rail (see p. A-5, below) in a government-approved transportation cask, at an average rate of about four a week for 20 years.

The rail cars would be off-loaded at the facility's proposed Canister Transfer Building (CTB), with each MPC being shifted (unopened) from the transportation cask in which it arrived into one of the storage casks that will have been fabricated on site. After being loaded with an MPC, each cask would be straddled and lifted by a massive, heavy-haul dual-tracked transporter vehicle that would move the cask to a position on one of the concrete pads.

2. Previous Aircraft Crash Decision. Nearly two years ago, we issued a Partial Initial Decision[3] on an earlier phase of this major safety issue raised by the State, which had intervened in the proceeding as part of its opposition to the PFS application for an NRC

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[2] Because this is the last decision we will issue in the proceeding, and it may lead to license issuance, we believe it appropriate -- for the benefit of reviewing tribunals as well as of those interested in how the agency conducts its business -- to devote considerable attention herein to the procedural and substantive history of the issue before us, given its significance to the people of Utah and the Nation (see the agency's Strategic Plan, NUREG-1614, Vol. 3, Part III ("Openness")(Aug. 2004), stressing the importance of effective outreach and communication as an adjunct to the agency's technical oversight of nuclear reactor and materials safety). In addition, all three Board members join in appending hereto information about the history of the proceeding which should be useful to various readers (see Appendix-1 to -15).

[3] LBP-03-04, 57 NRC 69 (Mar. 10, 2003).

license.[4] This safety issue, one of many presented to us by the State and now the last one pending, concerned the potential risk that accidental military jet crashes could damage the facility and thereby cause the release of radioactivity from the spent fuel rods held in the MPC.

The concern about such accidental crashes arose because pilots from Hill Air Force Base, northeast of Salt Lake City, annually make some 7,000 relatively routine flights down Skull Valley in F-16 single-engine fighter jets on their way to conducting intensive training maneuvers in the Utah Test and Training Range, located over the State's West Desert. Our earlier decision, following a lengthy evidentiary hearing, was that the probability of an accidental F-16 crash into the Applicant's proposed Skull Valley site was over four times too high to permit facility licensing (see Section 3, below) unless the potential consequences of such an accident were to be addressed in some fashion, such as by demonstrating their lack of significance or by guarding against them.[5]

3. "Credible Accident" Concept. The above-mentioned "probability" and "consequences" concepts come into play because nuclear facilities, such as power plants or spent fuel storage sites, must be designed to withstand all accidental events which are sufficiently likely to occur (while causing radiation releases in excess of specified limits) as to be deemed "credible" threats. Under the regulatory standard applicable here (see p. A-9, below), if the probability of such a radiation release from an accidental crash of one of the F-16s is less than one in a

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[4] The State's broadscale and enduring opposition to the PFS proposal has been manifested here and in other forums. In that regard, the United States Court of Appeals for the Tenth Circuit recently affirmed a federal District Court's invalidation of certain State statutes designed to block the facility. See Skull Valley Band of Goshute Indians v. Nielson, 376 F.3d 1223 (Aug. 4, 2004), affirming Skull Valley Band of Goshute Indians v. Leavitt, 215 F. Supp. 2d 1232 (D. Utah 2002), petition for cert. filed (Oct. 28, 2004) sub nom. Nielson v. Private Fuel Storage, No. 04-575. See also Bullcreek v. NRC, 359 F.3d 536 (D.C. Cir. 2004) (rejecting the State's theory that the NRC lacks authority to license a privately-owned away-from-reactor spent fuel storage facility).

[5] See LBP-03-04, 57 NRC at 77-78, 135. That first phase of the aircraft crash issue became known colloquially as the "probability" phase, and the current, second phase as the "consequences" phase. As will be seen, those categorizations turned out to be not fully descriptive. See p. 5, below.

million per year, such crashes need not be considered in designing the facility (in NRC parlance, are not "credible accidents") and therefore do not pose a barrier to licensing the facility.

The first portion of our proceeding addressed only the preliminary question of the probability of an accidental crash of an F-16 into the site,[6] for if that probability had proven to be less than one in a million, the Applicant would have prevailed without having to present further analysis. With the evidence showing that probability to be over four in a million per year, however, this second portion has focused upon a more refined question: whether there is a probability greater than one in a million per year that an accidental crash of an F-16 would have the consequence of breaching a canister and thereby causing a release of radiation.[7] For if not, the facility would need not be designed to withstand such an accidental crash and would not on that ground be denied a license.

4. Recent Aircraft Crash Hearing. In the aftermath of our first F-16 crash decision, and of the Commission's declining to review it at that juncture (CLI-03-05, 57 NRC 279 (May 28, 2003)), the Applicant attempted to show, at a 16-day evidentiary hearing before us in late

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[6] For purposes of determining that probability, a standard formula was employed (see p. A-12, below). See generally LBP-03-04, 57 NRC at 87-88, 114-22.

[7] As will be seen, the Applicant chose not to attempt to demonstrate that a radiation release, if it occurred, would not cause doses in excess of applicable limits (see pp. A-15 to A-16, below). Rather, it chose to hold itself to a more stringent test by attempting to establish that no radiation release whatsoever would result from any accidental crash deemed credible. See p. A-15, below.

summer, 2004,[8] that its storage casks were already designed robustly enough to alleviate the crash concern.[9] More specifically, the Applicant -- pointing to (1) the structure of the proposed storage casks and (2) the pattern of the actual F-16 crashes that have occurred worldwide -- urged that, even if an F-16 did crash into the site, such a crash was so unlikely to cause cask and canister damage resulting in radiological release that, under the "less than one-in-a-million" probability standard, the residual risk was an acceptable one to take.

Before the hearing began, the Applicant chose not to present evidence on possible radiological consequences from a breached canister, but to focus instead just on the probability that there would be no such breach. Accordingly, it could be said that this second phase of our hearing dealt not with classic accident "consequences" in a radiological release sense but with a consequences-oriented refinement, focusing on canister damage, of the initial site-related "probability" analysis. See p. A-15, below; LBP-03-04, 57 NRC at 78; and CLI-03-05, 57 NRC at 283-84. But see LBP-03-04, 57 NRC at 136 n.110, anticipating just such a segmentation of the issues.

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[8] As adverted to in note 1, above, and in the cover memorandum to the Public Version of this decision, that hearing had to be closed to the public to protect from disclosure certain information -- referred to as "Safeguards" because it involves safeguarding nuclear materials -- relating to analyses of cask characteristics, and the impact of aircraft crashes thereon, that could be of interest to potential terrorists. For similar reasons, the public will be able to review only the conceptual framework, not the detailed analysis, which supports our decision (see p. 9, below). Our detailed fact-finding and reasoning -- related to the extent, or lack thereof, of structural damage caused by aircraft impacts at particular speeds -- must be withheld from the public.

We would, however, point out to residents of Utah, and to other interested persons, that counsel from the State Attorney General's office participated fully in opposing the facility during the hearing. Counsel had the opportunity to challenge all the evidence in favor of the project and to present evidence on behalf of those opposed to it. Those same State counsel will now be in position to scrutinize, and if desired to challenge, our full decision. In that regard, that full decision, including the non-public versions being served on the parties today, will be available to any reviewing tribunals (see n.15, below).

[9] At one point, the Applicant sought approval to begin building an interim, smaller facility. That plan involved storing a reduced number of casks (336 instead of 4,000), thus taking up less space and presenting a smaller "target" area (see p. A-7, below), and arguably reducing the probability of a military jet crash to acceptable levels. The Applicant did not pursue that interim step after we initially rejected it on procedural grounds. See May 29, 2003 Tr. at 13729-855 (oral argument), 13857-59 (Board ruling); see also Tr. at 13859-75 (anticipating possible further proceedings).

Just as vigorously as the Applicant presented its position that the probability of a consequential breach-causing crash was low enough to be ignored, the State urged the opposite, through witness testimony and documentary evidence of its own indicating that the probability was too high.[10] The NRC Staff -- having, as part of its regulatory function, put a lengthy, time-consuming series of questions to the Applicant before the hearing -- came to the hearing essentially supporting the Applicant's position.

5. Today's Split Board Decision.[11] Upon review of all the evidence, Judges Farrar and Abramson find themselves essentially in agreement with the Applicant and NRC Staff on the key issues before us. As that majority of the Board sees it, the evidence -- including analytical and experimental data, and computer simulations based thereon -- establishes, based on the properties and shape of the concrete and steel "overpack" cask and of the stainless steel internal canister, that an F-16 crashing at or below a particular rate of speed and angle of impact (the "bounding impact," which is non-public Safeguards Information) would not damage a canister. Further, the nature of F-16 flights down Skull Valley, and the data that can be gleaned from the reports of prior F-16 crashes worldwide in circumstances akin to Skull Valley

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[10] With "risk" being made up of both probability and consequences factors, for simplicity it is often sufficient to focus on only one of those elements. Thus, if the consequences of an accident are shown to be not significant, no attention need be paid to the actual probability of that accident, for it does not matter if it occurs. Conversely, if the probability of an accident is sufficiently low, the consequences need not be examined, for even if they be assumed to be excessive, they need not be guarded against. (See the NRC Staff explanation preceding the opening of the Salt Lake City hearings (April 8, 2002 Tr. at 2997-99); our LBP-03-04 discussion (57 NRC at 138); and the Commission's explanation in an opinion herein, 57 NRC at 283-84.)

[11] In May 2003, the Commission expressed its belief that we should be able to issue today's decision by the end of that calendar year, i.e., nearly 14 months ago. See 57 NRC at 284-85. Much of the extra time, whose causes we reported to the Commission at each stage, was taken by the Staff's pursuit of additional questions in performing its pre-hearing regulatory review, and the Applicant's need for additional time to respond to those questions. In any event, all three Board members summarize in the Appendix our thoughts about the time consumed by this phase of the proceeding, both to complete the report the Commission expected, and to pass along our view that: (1) the extra time the parties took contributed much to the thoroughness and completeness of our evidentiary record; and (2) the course of this proceeding may be instructive in shaping expectations for future, similarly complex proceedings, especially in illustrating how large portions of time are outside Board control.

operations, reveal that there is over an 80% likelihood that the accidental crash of an F-16 into the site would be at a less severe speed and angle than the bounding impact and thus not damage a canister.

As a result, by virtue of the refined analysis presented by the Applicant and NRC Staff during the most recent hearings, the previously-determined over four in a million per year likelihood of a crash into the site (a relatively unsophisticated inquiry) has now been superseded by a more detailed inquiry. The latest analysis establishes that the likelihood of a crash causing a canister breach is somewhat less than one in a million per year.

Although the calculated probability seems to pass the applicable standard only marginally, the Board majority goes on to point out that there are at least four factors, not considered quantitatively in determining the probability, that can be seen qualitatively as serving to reduce that probability to an appreciable degree. These conservatisms involve: (1) the likelihood that, rather than being a "direct hit" causing the greatest damage, a crash could be off-center, a factor not considered in the evidentiary calculations; (2) the likely damage to an aircraft, and the reduction of its destructive force, that would occur if the plane hit short of the casks and skidded into them, a possibility that was analyzed at trial as though the crashing plane would continue unimpeded by its skid; (3) the possibility that before ejecting a pilot would attempt to direct the aircraft away from the site, a factor that -- although we declined to give the Applicant the "almost certain" credit for it being sought at the prior hearing -- has some support in the prior opinion testimony and anecdotal evidence and could thus justify some (albeit much smaller) credit; and (4) the possibility that the "bounding impact," below which canister breach was demonstrated not to occur, might upon further analysis be found to be slightly higher and thus move more crash scenarios into the "no-breach" category.

These additional conservatisms make the Board majority more comfortable with the degree to which the proposal meets the Commission's standards than it would be without them. On the other hand, Judge Lam's dissenting view is that there are too many areas -- including

the historic crash data, the expansive regression analysis, the curve-fitting methods, and the stainless steel behavior in the plastic range -- in which gaps in scientific and technical knowledge undercut the degree to which reliance can be placed on the evidence and the analyses. In his dissenting opinion, he explains why he is thus unwilling to credit the Applicant's and Staff's case sufficiently to approve the project.

6. PFS License Authorization Process. With our decision herein denying the State's assertions on the military aircraft accident issue, all the contentions raised by project opponents have now been considered by the Licensing Board[12] and resolved in the Applicant's favor in one fashion or another.[13] Thus, under agency rules governing facilities of this nature, it is now up to the Commission to determine whether to authorize the NRC Staff to issue the requested license.[14] Our decision is subject to review by the Commission and by higher tribunals.[15]

We build upon the foregoing Overview in Part I below (pp. A-1 to A-17) (Part I contains no Safeguards-related information and will thus be identical in each version of this decision). There we set out the procedural and substantive background that frames the parties' dispute.

In Part II, we provide our analysis of the evidence and explain how we arrived at the findings and reasoning outlined conceptually in this Overview. That discussion of the merits of

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[12] As will be detailed, the changing membership of the Licensing Board over the course of the proceeding has not affected our continuity of function.

[13] See LBP-03-04, 57 NRC at 84. Only now, with our rulings at an end, would some of our earlier rulings have ordinarily become appealable. But the Commission anticipated the need to conserve time when we eventually reached this juncture and previously called upon the parties to file their petitions for review of earlier Board rulings some time ago, rather than await today's completion of Board involvement. CLI-03-16, 58 NRC 360 (2003). The Commission has since addressed, and rejected, those asserted claims of error in our prior interlocutory rulings. See CLI-04-04, 59 NRC 31 (2004); and CLI-04-22, 60 NRC 125 (2004). See also CLI-03-08, 58 NRC 11 (2003) (affirming our earlier partial initial decision on seismic issues); CLI-04-16, 59 NRC 355 (2004) (addressing an earlier decision on financial issues).

[14] See p. C-2, below, citing 10 C.F.R. § 2.764(c); compare id. § 2.764(a)-(b).

[15] Our "Initial Decisions" are, as that term implies, not this agency's last word -- our rulings are subject to review by the five Commissioners who head the NRC and make the final decisions on behalf of the agency. Commission decisions are in turn reviewable by a federal Court of Appeals and may thereafter be considered by the Supreme Court of the United States.

the issue focuses on the three major sub-issues in the case: evaluating the strength of the cask structures; characterizing the historic F-16 crashes; and determining the uppermost probability that a crash into the site would have radiological consequences. (Because Part II is where "Safeguards" information appears, the *Public Version* of this decision contains only a brief, general, non-Safeguards summary, with pages numbered from B-1 to B-13. The complete reasoning in the *Safeguards Version*, available only to the parties and to reviewing tribunals, has pages numbered from B-1 to B-43.[16])

Based on the Part II analysis, we are able in Part III (pp. C-1 to C-7) to bring matters to a conclusion (Part III, like Part I, contains no Safeguards-related information and is identical in both versions). We there recite briefly our formal Conclusions of Law and our Order and add our closing thoughts.

Judge Lam's dissent appears after our decision. It was framed to avoid inclusion of Safeguards-related information, and thus its pages are numbered D-1 to D-7 in each version.

After that dissent, we present in an Appendix some ancient and some recent history about the case. The former relates primarily to other issues that were raised, and to certain principles that govern our proceedings, and is offered for the benefit of those who may not be familiar with those matters. The latter, intended to complete the report expected by the Commission (see note 11, above), indicates what occurred, and what was accomplished, in the time consumed since our first aircraft crash decision.

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[16] In our previous decisions herein, we included both a "Narrative" section addressing the crucial questions presented by way of an opinion, and another section that presented the more traditional and detailed "Findings of Fact." While this had the virtue of thoroughness, it did so at some cost in terms of both preparation time and overlapping rationales. Accordingly, we began discussing with the parties some time ago a different approach intended to shorten our decision-writing tasks at this juncture. See Tr. at 13912, referred to in our unpublished September 9, 2003, "Scheduling Order and Report," p. 7, n.10.

Although no specific resolution was agreed upon then, our decision herein is constructed differently from the earlier ones. We still employ a narrative format to explain the reasoning which leads us to the key determinations that drive our decision, but that narrative reflects only those findings that are relevant to the matters in issue, while omitting recitations of background or noncontroversial facts upon which all parties agree or which are not necessary for comprehension of the reasoning supporting our decision.

I. PROCEDURAL AND SUBSTANTIVE BACKGROUND

In this Part of our decision, for completeness but at the risk of repeating some of what appeared in the opening summary, we first review the procedural history of the litigation over the PFS application, with particular emphasis on the "credible accidents" contention now being decided on its merits. We next provide certain fundamental background information about the tangible aspects of the case: the Skull Valley geographic setting, the Air Force's training operations, and the Applicant's facility design. We then go on to recap the accidental aircraft crash decision-making process, including the manner in which our "probability" decision of two years ago, and the information-gathering since then, shaped the substance and timing of today's "consequences" decision.

A. Procedural History. The Applicant's proposal was noticed for hearing on July 31, 1997.[17] The State of Utah, along with a number of other parties, responded by requesting a hearing; eventually, those parties filed some 125 contentions challenging the proposed facility for various safety or environmental reasons.[18] On September 19, 1997, a Licensing Board was established to rule on petitions for hearing and for leave to intervene, and to preside over any adjudicatory proceedings that might be held in connection with the license application.[19]

The Board granted the State of Utah's request for a hearing, along with that of several other parties, and ruled that a number of contentions, in whole or in part, satisfied the Commission's requirements for admission as contested issues in this proceeding.[20] Other

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[17] See 62 Fed. Reg. 41,099 (1997).

[18] See LBP-98-07, 47 NRC 142, reconsideration granted in part and denied in part on other grounds, LBP-98-10, 47 NRC 288, aff'd on other grounds, CLI-98-13, 48 NRC 26 (1998).

[19] 62 Fed. Reg. 49,263 (1997). The Licensing Board was reconstituted three times during the course of the proceeding. Early on, Judge Murphy was replaced by Judge Lam. Later, a second Board was created with Judge Farrar as Chairman, but with the original Board, chaired by Judge Bollwerk, retaining jurisdiction over certain pending matters. Last year, Judge Kline was replaced by Judge Abramson on the Farrar-chaired Board. See 62 Fed. Reg. 52,364 (1997), 66 Fed. Reg. 67,335 (2001), and 69 Fed. Reg. 5374 (2004).

[20] See LBP-99-07, 47 NRC at 247-49.

contentions were raised and ruled upon from time to time thereafter, to which we need not pause to provide references. The last State contention arose very recently, in mid-November of last year; our ruling explaining why it did not warrant further consideration was issued earlier today. See LBP-05-05, 61 NRC ___ (February 24, 2005).

All but one of the contentions originally or later admitted have since been resolved through legal rulings, evidentiary decisions, or settlement agreements, leaving before the Board only the State's "credible accidents" Contention Utah K (its derivation is recounted at pp. A-4 to A-5, below). Of the 45 days of evidentiary hearings in 2002, a good portion was spent on what turned out to be the first phase of Contention Utah K. Our decision on those matters, issued March 10, 2003, eventually led to the second phase of the hearing, which began on August 9, 2004 and finished on September 15, 2004.

Owing to the sensitive information involved, the second hearing had to be closed to the public. That factor, along with the relative ease and assurance of document safeguarding at our DC-area headquarters location (as opposed to space obtained elsewhere), dictated that the closed hearing be held in our courtroom in Rockville, Maryland.[21]

Speeded somewhat by some novel techniques we employed (see App. 10-11, nn.17-20, below), the hearing took 16 days, during which we heard testimony from 18 witness panels, composed of various combinations of 20 different expert witnesses, who among them sponsored some 225 exhibits. That all generated some 4500 transcript pages of live

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[21] It should be noted that, although the hearings were "closed," they were not held in a "secretive" manner -- no information upon which our decision is based was unavailable to the parties, and no decision-makers met privately with any party. To the contrary, at all sessions, all three parties -- the Applicant PFS, the Intervenor State of Utah, and the NRC Staff -- were represented by counsel, and each had full opportunity to present its own witnesses, to cross-examine opposing witnesses, and to introduce (or to oppose the introduction) of documentary evidence.

A court reporter prepared a verbatim transcript of the entire closed proceeding. That Transcript, and all the other evidence in the case, has been available to counsel for all the parties, including the State, and will be available to the Commission and to any federal courts that may be called upon to review our decision.

exchanges, in addition to some 600 pages of pre-filed direct and rebuttal testimony that was, as is typical, bound into the record as if read.

The parties then submitted their two sets of post-trial briefs, in the form of opening and reply "Proposed Findings of Fact and Conclusions of Law" totaling over 900 pages. The last of those briefs was filed on November 19, 2004, and was thought to trigger the formal period for preparation of our decision.[22]

Upon examination of those briefs, however, we believed that an assertion by the State in its reply brief concerning an alleged serious deficiency in the NRC Staff position needed further exploration. Having heard nothing from the Staff, on December 1, 2004, we issued an "Order Directing Clarification of Record," calling upon the parties to provide us in rapid fashion additional position statements and record references that would clarify how the concerns we expressed were addressed in the record.

We duly received materials first from the State, then from the Staff and Applicant. The State then declined a chance to file a final response, expressing the view that it need not do so if no reliance was to be placed on what it viewed as additional materials the Staff had impermissibly provided without seeking to reopen the record.[23] At that point, we indicated in an email advisory to the parties that the State's filing, received December 22, would be deemed the final brief on the merits.[24]

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[22] The Commission urges that a decision should typically be rendered within 60 days of the filing of the final briefs. See Statement of Policy on Conduct of Adjudicatory Proceedings, CLI-98-12, 48 NRC 18, 21 (1998).

[23] NRC Staff's Response to Licensing Board's Order Directing Clarification of Record (Dec. 16, 2004) at 9-11, where the Staff urged that the State had impermissibly sought to reopen a closed record while, seemingly inconsistently, presenting its own new materials.

[24] See n. 22, above, and accompanying text. During the briefing period, the State had also sought leave to file a new contention based on information that had only recently come to its attention. The briefing of that matter overlapped with the briefing of the clarification we had sought related to the structural evidence. Similarly, the preparation of our decision on that new contention, issued earlier today (see p. A-2, above), overlapped with preparing this decision.

B. Pending Contention. The issue that has thus occupied so much of our attention the past several years had its genesis in the portion of consolidated Contention Utah K that concerned alleged "credible accident" scenarios that could result in impermissible radiological releases from the proposed storage facility.[25] The Board combined the State's contention with similar contentions introduced by two other parties[26] that raised similar issues regarding consideration of credible accidents.[27]

After a series of rulings,[28] Contention Utah K was winnowed down to the following:

> The Applicant has inadequately considered credible accidents caused by external events and facilities affecting the [independent spent fuel storage installation], including the cumulative effects of military testing facilities in the vicinity.[29]

In early follow-on rulings, however, the Board dealt with a number of aspects of those military operations.[30] Thus, as the time for trial approached, there were left, to be the subject of

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[25] See LBP-98-07, 47 NRC 142, 190 (1998).

[26] The consolidated parties were (1) Confederated Tribes of the Goshute Reservation and (2) Castle Rock Land and Livestock and Skull Valley Company (collectively Castle Rock), and the combined contention was originally designated as Contention Utah K/Castle Rock 6/Confederated Tribes B. See LBP-98-07, 47 NRC at 157, 247 (1998).

[27] As first consolidated, the Contention read as follows (see LBP-99-07, 47 NRC at 253):

> The Applicant has inadequately considered credible accidents caused by external events and facilities affecting the [independent spent fuel storage installation] and the intermodal transfer site, including the cumulative effects from the nearby hazardous waste and military testing facilities in the vicinity and the effects of wildfires.

[28] See LBP-99-34, 50 NRC 168 (1999); LBP-99-35, 50 NRC 180 (1999); LBP-99-39, 50 NRC 232, 237-38 (1999).

[29] LBP-99-39, 50 NRC 232, 240 (1999). On May 31, 2001, the Board granted in part, and denied in part, the Applicant's motion for partial summary disposition of various aspects of Contention Utah K. LBP-01-19, 53 NRC 416, 455-56 (2001).

[30] See LBP-03-04, 57 NRC at 86 (citing LBP-01-19, 53 NRC 416 (2001), which disposed of such matters as those related to general aviation, cruise missiles, and the use of military ordnance).

evidentiary presentations, only the matters eventually covered in our earlier "probability" opinion.[31]

C. Substantive Information. As seen above and in the Appendix, this litigation has a complex procedural background. In contrast, its substantive background may be described relatively simply.

1. Geographic Setting. Skull Valley is framed by the Stansbury Mountains to the east and the Cedar Mountains to the west. Its width varies, but for purposes of this general description the Valley can be regarded as some 10 miles wide. To the north of the Valley is the southern end of the Great Salt Lake. A bit south of the Lake, Interstate 80 runs in an essentially east-west direction (paralleled by the main line of the Union Pacific Railroad just to its north).

An exit from I-80 partway across the Valley provides access to Skull Valley Road, which runs north-south down the Valley all the way to the Dugway Proving Ground. Some 25 miles south of I-80, the road passes through the Reservation of the Skull Valley Band of Goshute Indians. The Band has leased some of its land west of the road to the Applicant for the proposed temporary facility for aboveground storage of spent nuclear fuel.

At one point, the Applicant planned to use Skull Valley Road as a truck route to bring the spent fuel on the last leg of the journey from various reactors around the country. But the Applicant later proposed to construct a rail spur, off the main line of the Union Pacific (which by then has cut south of I-80), down the west side of the Valley to the facility. After an evidentiary hearing on the environmental and wilderness issues involved, we rejected the Southern Utah Wilderness Alliance's challenge to that rail-line proposal. LBP-03-30, 58 NRC 454 (2003).[32]

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[31] In addition to considering the F-16s headed down Skull Valley, the evidence at the first hearing, and our decision thereon, involved possible site impacts stemming from flights on the so-called "Moser Recovery Route," emergency landings at Michael Army Air Field (at the Dugway Proving Ground), dropped ordnance, and operations in the Utah Test and Training Range itself. See 57 NRC at 122-32.

[32] Although we held that wilderness values were neither apparent in the area in question nor affected by the rail spur, we noted (LBP-03-30, 58 NRC at 475-76) that the final word as to wilderness designations lay with the U.S. Congress.

2. Military Operations. The matter before us arose because military aircraft from Hill Air Force Base, northeast of Salt Lake City, are regularly flown down Skull Valley on their way to the Utah Test and Training Range (UTTR), the nation's largest overland training area, located to the west of the Cedar Mountains in the State's West Desert. Put simply, the flights down the Valley are relatively routine in nature, as the pilots get themselves and their craft prepared to participate in very intensive training maneuvers in the UTTR, which they enter by, in effect, making a U-turn at the southern reach of the Valley. See 57 NRC at 110 n.68.

As this litigation developed, the focus came to rest on the 7,000 or so flights a year pilots make in the Valley in the F-16, a single engine fighter aircraft. Not surprisingly, the historic crash rate of that aircraft, and the causes of those crashes, as well as the speed and angle of the planes at impact, became the subject of extensive evidentiary presentations in the two sets of hearings we held on this subject.

Although we cover that evidence in detail in Part II below, it is worth noting at this juncture that a good proportion of F-16 crashes stem from engine failure. When faced with that emergency, pilots are trained to "zoom" their aircraft, thereby trading their forward speed for a higher altitude and therefore gaining more time to deal with the emergency. The planes' trajectory and the pilots' activities after the conclusion of the zoom maneuver were the subject of extensive testimony in both sets of hearings, and we discuss in Part II the extent to which the zoom maneuver and its typical aftermath help us in predicting patterns of crash impacts and angles.

3. Facility Design. As noted above, the Multi-Purpose Canisters (MPC's) containing spent fuel from various nuclear reactors around the country are to arrive by rail at the facility's Canister Transfer Building. There, each MPC would be removed from the transportation cask in which it traveled from the reactor to the site and place in a concrete and steel storage cask, fabricated on site, which would then be moved to the concrete storage pads by a massive transporter.

The storage area would employ 500 such pads, each 30 feet wide by 67 feet long, sized to hold eight cylindrical storage casks upright in a 2 by 4 array. The pads would be arranged in two cohorts, each consisting of 25 columns of 10 pads laid end to end. The two cohorts of pads would be separated by 150 feet.

The distance between each of the end-to-end pads in a column would be five feet. In contrast, the side-to-side distance between pads in adjacent columns would be 35 feet, providing a passageway for crawler access to the four cask locations on the nearer side of each pad to its left and right.

This pad/cask geometry comes into play, of course, in calculating both (1) the spatial parameters of the "target" that would be presented to a crashing aircraft (the "A" factor, representing site Area, in the screening formula (see p. A-12, below) that was a focus of the first phase of the aircraft proceeding), and (2) the subsequent interaction among casks, and between plane and casks, after an initial crash impact. For example, because the severity of impacts to the side of a cask depends on the flight angle, the array of casks closest to the approaching plane provides some degree of shielding to the casks behind them.

D. Decision Process. Contention Utah K's long history before the Board was set out in Section B, above. Two key steps we took along the way were to limit the scope of that contention by granting in part the Applicant's motion for summary disposition (LBP-01-19, 53 NRC 416) and, after lengthy hearings, to decide the "probability" phase of the contention (LBP-03-04, 57 NRC 69). We focus below on that latter phase, and the manner in which it led to the current phase.

1. "Credible Accidents." Stated simply, of concern during the first "probability" set of hearings was the likelihood of an accidental aircraft crash into the proposed facility, for nuclear facilities have to be designed against only those radiation-releasing accidents that are sufficiently likely to be deemed "credible." In other words, if the possibility of such an accidental crash occurring proved too remote, then the Applicant did not have to protect against that

possibility. To that simple statement, however, need to be added two explanations -- one very short, the other not so.

In the first place, long-standing Commission precedent circumscribes Board hearings by explaining that they are not the place to consider deliberate terrorist-type attacks. That precedent was followed here.[33]

Secondly, the "credible accidents" test deserves more explanation in light of the complicated, two-part proceeding that has taken place here. To go back to the beginning, the admission of the State's "credible accidents" contention required us, in theory, to undertake a detailed examination of the probability of radiation release from aircraft crashes. In that respect, the Commission has, over the years, developed a standard for determining which events must be considered in the design of nuclear power reactors.

For consideration of aircraft accidents, the standard is that "if the probability of aircraft accidents resulting in radiological consequences greater than 10 CFR Part 100 exposure guidelines is less than about" one in ten million per year,[34] that potential accident need not be considered in the design of the facility [35] (according to these guidelines, an event which must be

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[33] To be sure, one of the reasons behind closing our hearing to the public was to keep crash impact information and analyses out of the hands of those who might deliberately put them to nefarious use. But the scope of the hearing involved only the threat posed by accidental crashes, not deliberate ones. This limitation follows the agency's long-term practice, dating from the days of the Atomic Energy Commission (see Long Island Lighting and Power Co. (Shoreham Nuclear Power Station), ALAB-156, 6 AEC 831, 851 (Appeal Board, 1973)) and renewed after the events of September 11, 2001, that agency hearings are not the place to attempt to address concerns about terrorism. CLI-02-25, 56 NRC 340 (2002), discussed at 57 NRC at 78 n. 4.

Instead, protection of nuclear facilities against terrorism has been undertaken by the Commission itself -- outside the hearing process -- in conjunction with other federal agencies, civilian and military. In a word, then, the protection afforded the PFS site (or any site housing spent nuclear fuel) against deliberate aircraft crashes is viewed as coming not from a Board hearing attempting to evaluate that possibility, but from the federal initiatives attempting to prevent that possibility.

[34] See, e.g. CLI-01-22, 54 NRC 255, 260 (2001), referencing NUREG-0800 at 3.5.1.6, wherein the quoted material is set out.

[35] NUREG-0800, Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants (Rev 2) (July 1981) at 3.5.1.6, Section I, and Section II, subsection 1, final paragraph (stating the converse).

considered is referred to as a "design basis event" or a "credible accident").[36] Because of the nature of the facility at issue here, however, the Commission established a different threshold probability for a design basis event -- at a PFS-like facility it is one in a million per year, rather than the one in ten million standard applicable to nuclear power reactors.[37]

A key to understanding this stage of the proceeding involves appreciating that, while prior rulings may have referred -- in shorthand fashion -- simply to the probability of an aircraft crash into the site, what is now (and always has been)[38] at issue is the probability of a radiation release caused by such an aircraft crash. In other words, the event that has to be guarded against is an accident causing a release. This is what the Commission addressed, and it is the event that was examined and described in the Standard Review Plan (NUREG-0800) to which the Commission referred in ruling that the appropriate threshold probability for a PFS-like facility is one in a million (the "designated threshold").[39]

To our knowledge, in every previous case before a Licensing Board (and/or the Commission), the determination as to whether or not a potential radiation release from an aircraft crash was a "credible accident" was resolved by simple examination of the probability of a crash into the site. For if that probability itself is lower than the threshold, the inquiry need go

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[36] See, e.g., CLI-01-22, 54 NRC at 259.

[37] At the outset, based on pleadings the parties had filed with us, we sought the Commission's formal guidance on whether the standard determining the credibility of accidents that might affect nuclear power plants -- one in ten million per year -- should be relaxed for facilities like that proposed by the Applicant here. The Commission responded by setting the one in a million standard, meaning that this facility need be concerned only with events ten times more likely to occur than the even rarer ones that nuclear power plants need to guard against.

More specifically, we made an initial ruling on the design standard for accidental aircraft crashes at the proposed facility and found that the facility need not be designed to withstand aircraft crashes having less than a one-in-a-million (1×10^{-6}) chance of occurring. See LBP-01-19, 53 NRC at 430-31 (2001). But recognizing the novelty of that ruling, and the pivotal role that it would play in the eventual outcome, we sought formal advice by referring our interlocutory ruling to the Commission for its determination. The Commission accepted our referral and upheld our determination. CLI-01-22, 54 NRC at 257 (2001).

[38] See LBP 03-04, 57 NRC at 136.

[39] Ibid.

no further -- regardless of the potential radiation consequences, the sheer unlikelihood of the accident's occurring at all removes any need to look into how severe it might be. This led to the shorthand way of describing the issue.

On the other hand, if the probability of a crash itself were known in advance to exceed the designated threshold (i.e., the acceptable probability of a radiation-releasing event), an applicant might typically elect not to pursue the site further through the application process, much less the adjudicatory one. That election might be made even though an aircraft crash into a site does not make it certain that radiation will be released (the crash might not hit a radiation-confining structure or, if it did, the structure might not be breached). To our knowledge, no case has been heard before a Licensing Board or the Commission wherein the probability was close to the designated threshold -- because, we speculate, sites for which the probability was seen to be close were rejected by the applicants a priori and they chose, for any number of possible reasons, not to pursue inquiry about such sites any further.

Here, we previously found that the probability of a crash into the site did indeed exceed the designated threshold. Rather than abandon the effort, however, the Applicant (eventually supported by the Staff) took a legitimate but unusual approach -- taking a closer look at the crash sequence to determine the probability, not just of a crash, but of one that would release radiation. In doing so, the Applicant expected to be able to establish that the vast majority of aircraft crashes into the site would not rupture an MPC contained in a cask, and therefore would not release radiation, and therefore would not need to be designed against, notwithstanding the initial site-focused determination appearing to point the other way.

A site-focused probability determination begins with a classic "four-factor formula," which we describe elsewhere (and which the parties to this case accepted as the appropriate way to compute that probability). Use of that formula serves only to determine the probability of a crash into the site, which was all that was involved in our mid-2002 hearing. At that hearing, we were to determine whether the chance that an aircraft would crash into the proposed facility

was (1) greater than 1 x 10^{-6}, in which case the facility would have to be shown (or redesigned) to withstand the event without significant radiological release, or (2) less frequent than 1 x 10^{-6}, in which case the accident would be deemed not "credible," meaning its occurrence and its consequences could be safely disregarded.[40]

After our March 2003 decision on that issue went against the Applicant, the unusual -- but appropriate -- next step was that, at the Applicant's instance, we were asked to hear evidence on the details of such crashes, studying the spectrum and effects of such crashes and evaluating which crashes would (or would not) cause radiation releases. That examination involved considerations enormously more complex than has been the historical norm. We discuss both hearings in more detail below, devoting considerable attention to the previous hearing because of its relationship to the current one.

2. "Probability" Hearing and Decision. After the Commission set the design basis threshold probability at 1 x 10^{-6}, the factual issues were ripe for consideration by the Board. Although other military operations were also considered, the primary focus of the hearing was on the F-16 flights from nearby Hill Air Force Base that were passing over Skull Valley on their way to the UTTR.

At the heart of that hearing was the aforementioned four-factor screening formula that the NRC Staff has long used to calculate the risk of an aircraft crashing into an NRC licensed facility.[41] Although the parties disagreed mightily as to what the evidence showed as to the

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[40] Ibid.

[41] The formula is contained in the "Aircraft Hazards" portion of the Staff's Standard Review Plan, NUREG-0800.

values to be assigned three of the factors, they accepted that the formula itself appropriately focused on those factors as the starting point for our evaluation.[42]

The formula's notation is $P = C \times N \times A/w$. Those designations represent that the probability (P, in accidents per year) is determined by multiplying the aircraft's historic accident rate (C, in accidents per mile) by the number of flights per year (N) and by the effective area of the facility (A, in square miles) divided by the width of the airway (*w*, in miles).

The parties presented extensive evidence and arguments about the value we should assign to three of the factors (A, the site area, was not contested). But it became clear early on that, even if the Applicant's values were accepted, it would be unable to prove via the formula that an accidental crash into the site had less than a 1×10^{-6} chance per year of occurring.[43]

This led to the Applicant's attempt to gain acceptance for adding a controversial fifth factor -- the so-called "R" factor -- to the standard screening formula. Intended to reduce the site impact probability, the R factor seeks to account for asserted "pilot avoidance" conduct, i.e., the claimed action pilots would take, if able to do so, to guide their planes away from vulnerable ground sites before ejecting in an emergency where a crash was likely.

The State made two arguments against the Applicant's R factor. In short, those arguments were that (1) the four-factor formula devised by the Staff was well-established and did not allow for a fifth factor and (2) the value that the Applicant wanted to assign to R -- an 85 percent reduction in accident likelihood -- was not supported by the evidence. LBP-03-04, 57 NRC at 90.

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[42] At the outset of the "consequences" phase, Judge Abramson -- who had been assigned to the case after the "probability" phase -- asked the parties whether the formula, long-used as a rough "screening" device for determining the acceptability of a site, should also be used to determine more precise probability matters (Tr. at 17720). That question would be lingering here, but for the parties' unmistakable agreement that the case should be decided by application of the formula (Tr. at 17720 (Turk), Tr. at 17720-21 (Barnett), 17729 (Soper)).

[43] Of course, had the one in ten million standard applicable to nuclear power plants been retained as the guidepost, the Applicant would have been 10 times farther away from a showing of compliance. In this regard, see App-5, n.8, below.

The Board rejected the State's first argument that the formula could not be changed.[44] We did agree, however, with the State's second argument, that the evidence regarding the R factor did not justify the massive reduction in probability that the Applicant sought.

In doing so, the Board evaluated the R factor on the Applicant's terms, considering how often F-16 pilots are in control of their aircraft during an emergency (R1) and how often pilots in control will attempt to steer the plane away from something on the ground before ejecting (R2). The Board accepted the Applicant's R1 evidence that, taking into account only the F-16 crashes that are "Skull-Valley type events" (that is, crashes that occurred in circumstances that could also exist in Skull Valley flights), pilots are in control of their planes 90 percent of the time. Id. at 98-99.

In evaluating R2, however, the Board determined that the Applicant's assertion that pilots will attempt to steer away from objects on the ground in 95 percent of the cases was unfounded. Id. at 99-110. We found that the theory (based on expert opinion, not actual data) that a pilot will, with almost absolute certainty, avoid the facility when in an emergency situation and under considerable stress had not been established. Id. at 100, 107-09.[45]

In other words, the Board determined that the evidence setting a high value for R2 was too uncertain to be relied upon in making a safety decision for nuclear facility licensing. Thus, the Board did not accept the Applicant's and Staff's position on the R factor, and instead relied on the traditional four-factor formula in evaluating the probability of an crash into the proposed facility.

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[44] We reasoned that, while the original formula does not explicitly contemplate the R factor, neither is consideration of such a factor legally prohibited, such as by way of agency regulations or Commission precedent. Therefore, we reasoned, as long as the addition of the R factor has a factual and technical justification, then it could be added to the standard probability formula. Id. at 91-93.

[45] Although we rejected it for the purpose and to the extent then offered, we did not indicate that the theory had no merit whatsoever. We return to it for another purpose later (see the portion of Part II setting out several conservatisms supporting our decision).

The Board applied the four-factor formula to all of the State's proposed accident scenarios, including F-16 crashes into the facility, other airplane crashes into the facility, and ordnance strikes into the facility. We determined that the evidence was insufficient to establish that the accidents had less than a one-in-one million chance of happening.

To the contrary, we found through use of the formula that the probability of an F-16 impacting the facility is 4.29×10^{-6}, that is, the probability of such an accident is more than four times greater than the standard for a "credible accident" set by the Commission. Id. at 122.[46] Thus, we determined, the Applicant had failed to establish that an aircraft crashing into the facility was not a "credible accident." The Applicant was therefore left to establish, in a subsequent "consequences" phase of the hearing, that the design of the facility is robust enough so that a crashing F-16 would not penetrate a cask or that, if it did, that there would be no significant radiation impact for the public. See p. 3, above.

3. The "Consequences" Hearing. After we decided in LBP-03-04 that the probability of a crash of an F-16 fighter jet from Hill Air Force Base into the Applicant's site was too high to permit facility licensing, the Applicant and Staff took an appeal to the Commission, as we had indicated might be appropriate at that juncture. Id. at 142-44, 231. In response, the Commission exercised its discretion to decline review of our "probability" decision until we heard the "consequences" part of the contention. CLI-03-05, 57 NRC 299, 282-84 (2003).[47]

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[46] Of course, given the lack of absolute precision in the values found for the formulaic factors (see discussions in our previous decision regarding crash rate, width of airway, and number of flights), the "4.29" result may appear more precise than it is. Regardless of the number of significant digits, the point is the same -- the Applicant's proof failed by a factor of over four.

[47] As we were preparing for that hearing, the Commission, which does not usually encourage wholesale interlocutory appeals, decided to do so at that stage of this case to "expedite the final stages of a licensing process that has dragged on for a number of years." CLI-03-16, 58 NRC 360 (2003). As a result, challenges to many prior Board rulings in this proceeding were considered and rejected by the Commission last year. See n. 13, above.

The Commission noted that it expected the consequences proceeding could be completed by the end of 2003. Id. at 284-85. We will return to that point, but need first to indicate what transpired at the beginning of that proceeding.

a. Scope of Hearing. At the outset of this "consequences" phase, the State sought to define its scope broadly enough to allow for the presentation of evidence on the radiological consequences that would result from the breach of a cask's MPC. The Applicant argued, however, that the scope of the consequences phase should be more narrow, limited to the Applicant's effort to demonstrate that the probability of such consequences left an MPC breach as a non-credible event. Under that view, it was said, radiological consequences would not need to be examined in detail.

We had foreseen, in our first decision, the possibility of this type of disagreement as we moved ahead. Colloquially, all had talked about a two-part proceeding, one involving "probability" and the other embracing "consequences," those being the two factors in a risk determination. But we had noted that the risk question could more precisely separated into three parts: probability of a crash into the site, leading to cask/canister breach, leading to radiological consequences. LBP-03-04, 57 NRC at 136 n. 110. As we observed, depending on how the second factor was defined, it could be viewed as either part of the probability (of a cask breach) calculation or as part of the consequences (of a site impact) analysis. Ibid.

In that light, we did not view it as necessarily an impermissible approach to separate consideration of the second factor from the third one. At that point, the State was ready to, and pressed to proceed on, the third factor. The Applicant and Staff indicated they were unprepared to do so. We made the pragmatic, time-saving decision to have the hearing focus on only the second factor.[48] But we took two additional actions as well.

[48] See unpublished Memorandum Concerning Scheduling (Apr. 15, 2004) at 3-4.

First, we indicated that the State would be permitted to make an offer of proof, pursuant to 10 CFR § 2.743(e), at the outset of the hearing. The State in fact did so. See Tr. at 19689-90.

Second, the Board Chairman advised the Applicant and Staff that, given the posture of the case, their unreadiness to proceed may have engendered lasting prejudice to their cases. Specifically, they may have forfeited any opportunity to address the radiological consequences issue later, if they were unsuccessful on the MPC-breach matters on which they were ready to proceed to trial. See Tr. at 19666-77; unpublished Memorandum Concerning Scheduling (Apr. 15, 2004) at 4.

Against that background, we need add only that the reason we did not entertain the evidence the State proffered is that -- even though the Applicant does not characterize it this way -- in essence the Applicant is, for purposes of this phase only, not challenging the notion that the radiological consequences of an MPC breach could be beyond acceptable norms.[49] But because in its view the probability of such a breach is below one-in-a-million, then even if the probability of excessive consequences of such a breach is taken as a certainty (expressed as unity), the overall risk of an accident that results in excessive radiological releases (being the product of the two factors) remains at less than one-in-a-million. For that reason, the evidence reflected in the State's offer of proof was, and remains, rejected as not material to the more narrow issue before us.

b. Result of Hearing. Put in layman's terms, the Applicant's approach at the hearing was a simple one. As noted above, we had held at the end of the first hearing that the

[49] Specifically, the Applicant does not concede, as a factual matter, that even its "unanalyzed events" (see Part II, below) would lead to any, much less excessive, radiological releases (although it does not argue that there is no speed at which a crashing F-16 would breach a canister). In contrast, our analysis in the text above is performed "as if a conservative assumption were made" that such a breach does occur for the accidents that are not "credible," simply to demonstrate how the "probability times consequences equals risk" formulation jibes with the regulatory standard. LBP-03-04, 57 NRC at 138, citing Staff explanation from April 8, 2002 oral argument.

probability of an accidental F-16 crash into the site was just under 4.3 in a million per year. In essence, by analyzing (1) the structural characteristics of the casks and (2) the impact speeds and angles of the applicable universe of historic F-16 crashes, the Applicant attempted to show at the second hearing that there is at least an 80 percent chance that a (hypothetical) future crash into the site would not breach an MPC holding the spent fuel.

If that showing were successful, it would of course point to the converse existence of at most a 20 percent chance that a crash into the site -- itself only a 4.3 in a million probability -- would breach an MPC. Taking the two factors together would yield no more than a .86 (less than one) in a million chance of anything that would cause a radiological release, and success for the Applicant.

In Part II, below, we explain why our decision today essentially holds that the Applicant's evidence established its point. Before turning to the merits, however, we think it important to explain why we are rendering this decision now, rather than much earlier.

c. Timing of Hearing. The Commission's "year-end 2003" goal for our decision was not able to be met, despite the best efforts of the Board and all counsel involved. This was in large part due to (legitimate) extra time consumed by the Staff's Requests for Additional Information from the Applicant, and the Applicant's revisions to its license application, all as reflected in the periodic orders we issued at different stages.

We might leave it at that. But the Commission has placed extensive emphasis in recent times on the need for expedition in the adjudicatory process, and this last phase has taken far longer than the Commission expected -- in a proceeding that it described a while ago (see n. 47, above) as having already "dragged on" for a long time. Thus, we think we owe it to the Commission, which asked us to report on this subject (CLI-03-05, 57 NRC at 285), to shine additional light on the matter. We do so in the Appendix to this opinion.

II. THE MERITS

SAFEGUARDS INFORMATION REDACTED [XXXXX]

Before this Board is the question of whether the release of radiation arising out of the crash of an F-16 aircraft (taken together with the impact of ordnance jettisoned from such a crashing aircraft) into the facility is a "credible event." For the purposes of evaluating this matter, the Commission has set as the standard[50] that if the probability of such an occurrence is less than 1.0×10^{-6}, it would not be a credible event.[51] If such an occurrence is not a credible event, it is not part of the "design basis,"[52] and therefore there is no need to engineer the facility to accommodate (withstand) such an event.

1. The Analytical Background. In prior hearings, the parties presented evidence on, and the Board considered, the probability that an F-16 (or the ordnance it carries) would crash into the PFS site. The Board found that there was a 4.29×10^{-6} probability of that occurrence.[53] Similarly, the Board found that there was a 2.11×10^{-7} probability of jettisoned ordnance hitting the site .[54] Since the Board had determined that this probability exceeded the threshold for treatment as a design basis event, the Applicant elected to look further at the probability evaluation, reasoning that an aircraft or a piece of ordnance which hits the site will not necessarily impact on and breach one of the spent fuel storage casks and thereby cause a release.[55] Thus the Applicant continues to attempt to demonstrate that the probability of

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[50] CLI-01-22, 54 NRC 255, 257 (2001).

[51] For ease of reference, we will use the scientific notation throughout this decision.

[52] See 10 CFR Part 72, Subpart E and F.

[53] LBP-03-04, 57 NRC 69, 122 (2003).

[54] Id. at 131. We note, however, that the prior Board did not consider the fact that some of the aircraft involved in jettisoning their ordnance will carry more than one piece of ordnance, a fact which needs to be considered in the present evaluation.

[55] See Part I, above.

occurrence of the events in question is so low that these events need not be considered in developing the design of the facility.[56]

Therefore, in the present portion of this hearing, the parties have addressed whether an aircraft (or ordnance which is jettisoned from an aircraft) which crashes into the PFS site will impact and breach a cask. In doing so, the parties have made a number of assumptions (discussed in depth below).

The issue before us involves the limited safety question of whether the canister will, in a crash situation, maintain its integrity as a radiation boundary, and not whether it would, when subjected to a lesser crash impact which causes no radiation release, keep the spent fuel bundles from sustaining any damage. In that regard, an incident which does not release radiation, but nonetheless causes the overpack and the MPC to be so damaged that the fuel contained within the MPC is no longer intact, may well be significantly more likely than one which is so damaging that radiation is released. But such incidents are not at issue here. Under the regulatory system, such incidents -- because they are not radiation releasing -- are to be dealt with by a licensee if and when they occur. Under that circumstance, the agency will become heavily involved (as it does in the aftermath of any accidents) to assure that possible effects of radiation arising out of the recovery operations are safely handled. Such incidents may present a serious problem in terms of what it takes of a licensee to clean up, but with no radiation "consequences," they do not have to be designed against.

Rather than attempt to examine every possible event and then determine which events cause a breach and from that determine the probability of a breach, the Applicant elected to examine the inverse problem -- the Applicant has attempted to delineate a set of events which it alleges do not cause a breach. Since the universe of events can be divided into breach and

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[56] See Part I, above.

non-breach, the probability of a breach would be no more than 1.0 minus the probability of the set of events which are determined not to breach.[57]

While the Applicant does not claim that it has thus defined all events which do not breach a cask, it takes the view (**with which we agree**) that so long as the probability of the remaining unanalyzed events (referred to as the Unanalyzed Event Probability or "**UEP**") is less than the 1.0×10^{-6} threshold, it need not examine any of those events -- for it will have already established that the probability of a breach is less than the threshold and therefore that a breaching event is NOT a design basis event. This approach -- if successful -- would allow the Applicant to bypass the difficult task of assessing how, if there were a breach, the different radioactive nuclear materials in the MPC would be released, dispersed and find the pathways into the human population at site boundaries, an issue which the State wished to litigate.[58]

2. The Technical Approach. The technical problem has been divided into two basic pieces: first, examine the physical effect a crashing aircraft or falling ordnance has, at a particular speed and angle, on the steel lined cement "**overpack**" cask, to determine whether or not that impact damages the stainless steel Multi-Purpose Canister ("**MPC**") contained within the overpack -- either through penetration of the overpack by the incoming aircraft or ordnance, or via a dynamic interaction between the overpack and the MPC, thereby (in either case) causing release of radioactive byproducts contained within the MPC (the foregoing being referred to as the "**structural analysis**");[59] and second, examine the probability of the incoming

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[57] We say "no more than" because, by definition, we have no information on any of the events which have not been examined. Therefore, it is not known whether any particular event in that set would or would not cause a breach, but for purposed of the Applicant's theory it would not matter if they did.

[58] See Part I, above.

[59] The principal consideration for this category of events is whether or not radiation is released. Therefore, independent of the degree of damage sustained by the overpack, the sole consideration for this analysis becomes whether or not the MPC retains its integrity as a containment vessel. Thus the overpack could be viewed, for this particular analysis, as one of
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aircraft or ordnance impacting on the overpack at a speed greater than the highest (as determined in the structural analysis) non-breaching speed and at an angle XXXXXXXXXXXXX to the surface than the "critical" angle[60] (this latter analysis being referred to as the "**probability analysis**").[61] The structural analysis is then used to establish what amount to "set boundaries" for the probability analyses to enable computation of the probability of the set of non-breaching events, which are bounded by the "worst case" non-breaching event which has been analyzed (for the purposes of this discussion, the "**bounding event**"). Having so determined the probability of the non-breaching event set, which is bounded by the chosen "worst case bounding event," the probability of the breaching set (i.e., the UEP) is then bounded as 1.0 minus the former.

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[59](...continued)
the "barriers" protecting the spent fuel and fission products from release from their confinement within the MPC, by interfering with the incoming airplane or ordnance before it impacts the MPC.

[60] The analyses indicated that, for impacts on the side of the overpack, aircraft impacting XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX, and therefore the parties have mutually assumed, for the purposes of this analysis, that if an aircraft impacts at an angle equal to or greater than, and at a speed equal to or less than, those for which analyses demonstrate non-failure, those impacts would also not cause failure. We find that approach to be scientifically sound, and hereby adopt that hypothesis.

[61] A thorough discussion of this approach is set forth in Applicant Exh. 265: C. Allin Cornell, Probability Assessment of the Aircraft Crash Impact Hazard for the Private Fuel Storage Facility Based on Engineering Evaluations of Storage Cask and Canister Transfer Building Structural Integrity (Rev. 1) (Jan. 2004) [hereinafter Cornell Report], including, among other things, the method for incorporating the effects of angle and azimuth of impact and the effective areas of storage cask tops and sides.

3. The Structural Analysis. The Applicant and the Staff have examined a series[62] of hypothetical radial impacts[63] by aircraft traveling at speeds of XXXXXXXXXXXXXXXXXXXX

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[62] The Applicant provided 12 analyses (10 of which modeled radial impacts on the casks). The Staff reviewed the Applicant's analysis, and also contracted with Sandia National Laboratories to perform an independent analysis to confirm the Applicant's results. All of the "examinations" have been through the use of LS-DYNA, a sophisticated computer code intended for use in the analysis of complex dynamic structural loading scenarios (i.e., there is no direct experimental evidence on the entire scenario, although there is substantial experimental evidence supporting most of the models and modeling assumptions in the codes as used herein).

There is an old adage among the developers and users of computer codes for complex engineering problems that everyone believes the computed results obtained from such codes except the people who wrote them. In this instance, all parties were "users" of these codes, but none were developers of the codes in question, and each party challenged the results obtained by the other for a variety of reasons.

However, the Staff's consultants performed "confirmatory computations" using their computer codes to make a determination regarding the general accuracy of the computations performed by both the Applicant and the State. In most instances, the computer "models" (numerical representations of the "Problem" to be analyzed) developed by the Applicant differed in material ways from those developed by the State, and therefore direct comparison of computed results was impossible. Nonetheless, all parties attempted to model the scenarios at issue; the differences in their modeling essentially amounted to different assumptions about what and/or how particular components or phenomena needed to be modeled. The record is replete with testimony and documentation of the results of those computations and the differing views regarding sources of uncertainty or conservatisms in the computed results.

A common thread runs through these analyses: independent of the particular computer model and the particular computer code, they all result in prediction of a maximum strain in the MPC (defined in the text of this ruling) and those maximum strains all fall within a certain maximum. In the present case, the overriding (and underlying) issue is whether or not the MPC can withstand such a strain without failure to retain its containment capability. Thus we are able to focus on that particular issue, and are not forced to deal with the question of which analysis method is the most accurate.

[63] While it is obvious that not all impacts would be radial, this conservative assumption is deemed by the Applicant and the Staff XXXXXXXXXXXXXXXXXXX. The State has argued that the incoming aircraft or ordnance might ricochet off the first cask if it does not impact radially, and would also cause some torque to be applied to that cask, but has not presented any analyses to demonstrate that the results of a secondary impact could be as severe as the primary impact nor that the results of a non-radial primary impact would be expected to be more severe than those of a radial impact. We find that there is sound reason to believe that the effects of the primary impact upon the incoming aircraft or ordnance would deform and break up the impacting object such that a secondary impact could not be as severe as the primary impact. Therefore, we agree with the Applicant and the Staff that XXXXXXXXXXXXX by a non-radial impact would be bounded by that caused by a radial impact, and, therefore, that there is no need to delve into the issue of what damage would be caused by a secondary impact because the associated primary impact which has been analyzed indicates the maximum damage which could be expected to the MPC in such an event. Furthermore, we are
(continued...)

XXXXXXXXXXXXXXXX.[64] According to their most recent analyses, such crashes do not result in material penetration into the overpack, and result in maximum tensile strains in the MPC below 10 percent.[65] The Applicant and the Staff conclude from this that all the events impacting at a lower speed or at a greater angle XXXXXXXXXXXXXX would not cause a breach of the MPC.[66] Without, at this point, either accepting or rejecting the computed results for the "bounding event" as presented by the Applicant, we subscribe to this analytical approach.[67]

The State submitted numerous aircraft impact analyses (also assuming radial impact), but some of these were shown to have had modeling errors; accordingly the State's last analysis --

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[63](...continued)
persuaded that there must exist, in the set of events, assumed to be purely radial impacts, a number of non-radial impacts which are essentially glancing blows which would have XXXXXXXXXXXXXXXX effect than a pure radial impact. Therefore, the assumption that all impacts are radially is markedly conservative XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX.

[64] See Testimony of Alan I. Soler on the Structural Effects of a Potential F-16 Impact on a Spent Fuel Cask Contention Utah K/Confederated Tribes B (July 12, 2004) at 18-19, 20 [hereinafter Applicant Direct Testimony on Structural]; NRC Staff's Testimony of Gordon Bjorkman, Robert Shewmaker, Robert Kalan, and Kenneth Gwinn Concerning the Consequences of an Accidental F-16 Aircraft Crash into a Hi-Storm 100 Cask at the Proposed PFS Facility (July 12, 2004, as revised August 6, 2004) at 13 [hereinafter Staff Direct Testimony on Structural (Bjorkman, et al.)].

[65] See Tr. at 19606 (Staff witness Bjorkman noting that all the parties found maximum tensile strain in the MPC to be below 10 percent). The Staff calculated a maximum actual true strain in the MPC of 8.5 percent. See NRC Staff Rebuttal Testimony of Gordon Bjorkman, Robert Shewmaker, Robert Kalan, and Kenneth Gwinn Concerning Cask Structural Issues (July 29, 2004, as revised August 9, 2004) at 7-8 [hereinafter Staff Rebuttal Testimony on Structural (Bjorkman, et al.)]; Tr. at 16941, 17128 (Kalan). The Staff at various points in its testimony presented an estimated plastic strain in the range of 10-20 percent (see Staff Direct Testimony on Structural (Bjorkman, et al.) at 15; Staff Exh. 67, Confirmatory Structural Analyses of an Accidental F-16 Crash Event Onto the Proposed Private Fuel Storage Facility (HI-STORM 100 Dry Cask Storage System) (May 11, 2004) at 54; Tr. at 16736 (Gwinn). The Staff's experts concluded in their rebuttal testimony that, while the there are higher strain values in the upper corner of the MPC where it strikes the rigid wall of the overpack, these strains are compressive and are not a threat to the integrity of the MPC; rather, the tensile strains, at 8.5 percent, in the MPC shell are the most important strains to consider when evaluating the structural integrity of the MPC post-impact. See Staff Rebuttal Testimony on Structural (Bjorkman, et al.) at 7-8.

[66] See note 60, above.

[67] For an explanation of tensile strains and other matters related to the ability of materials to withstand forces, see note 86, below.

of an aircraft impacting the overpack at a speed of XXXXXXXXXXXXXXXXXXXXXX from the horizontal,[68] presented during our September 2004 continuation of these hearings -- was the only one upon which we can place reliance.[69] None of the State's analyses (even those with modeling errors) indicate that an aircraft materially penetrates the overpack, and that latest analysis indicates a maximum tensile strain in the MPC of approximately 5.9 percent.[70] Thus, although the scenarios evaluated, and the modeling employed, by the parties are different, there is a common result for aircraft impact that the maximum tensile strains predicted to occur in the MPC are less than 10 percent.[71]

The results for ordnance impact are, however, not so easily compared. On the one hand, the State's analyses of ordnance, using the Applicant's suggested "corrections," assumed the impacting XXXXXXX bomb-class was completely rigid and that the steel in the overpack lid had weak material properties.[72] This resulted in a computation indicating that XXXXXX -class bomb impacting the cask at XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX

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[68] See Tr. at 19448 (Bjorkman).

[69] See Tr. at 17623-25 (Aramayo). All of the State's prior analyses indicate a form of numerical error which resulted in computation of unphysical gross very localized distortion of the fuel basket, thereby causing the code to compute large deformations of the MPC because of its computed interactions with the fuel basket. When the input assumptions causing those numerical errors were corrected by the State in this last "run", that phenomenon was no longer present in the computed results. See id. at 19269 (Aramayo).

[70] See Tr. at 19460 (Bjorkman), 19504 (Hoffman), 19506 (Sozen).

[71] See Tr. at 17128 (Kalan confirmed the Staff's maximum tensile strain in the MPC), 19460 (noting State's maximum tensile strain in the MPC), 19606 (Bjorkman stating all parties agree that the maximum tensile strain the MPC will be under 10 percent).

[72] See State of Utah Testimony of Mete A. Sozen, Christoph M. Hoffman, and Sami Kilic for Contention Utah K/Confederated Tribes B Cask Breach Probability Proceeding (Structural) (July 12, 2004) at 21 [hereinafter State Direct Testimony on Structural]; Tr. at 16535-36 (Kilic); see also State of Utah Rebuttal Testimony of Mete A. Sozen, Christoph M. Hoffman, and Sami Kilic for Contention Utah K/Confederated Tribes B Cask Breach Probability Proceeding (Structural) (July 29, 2004) at 6 [hereinafter State Rebuttal Testimony on Structural].

XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX, and maximum strain in the MPC of 14 percent.[73]

On the other hand, the Staff's consultant's analysis modeled the bomb (after correcting certain input errors) as if it were made up of the actual materials at design thicknesses and strengths (i.e., a "deformable" bomb, not a rigid one), and used true stress strain properties for the overpack steel lid.[74] These results indicated that there would be very little penetration into the overpack lid as the bomb deformed and disassembled, dispersing its non-explosive content.[75]

In an effort to identify how much of the difference in the above results was due to rigidity of the bomb and how much was due to the assumed material properties for the overpack steel lid plates, the Staff and the State made computations in which they used the same computer code and input (including the "rigid" bomb model) but changed the State's original input for the properties of the steel which makes up the top of the overpack lid to utilize steel structural response functions closer to a "true stress strain" curve (which is required by the computer code).[76] These analyses used somewhat different steel properties, resulting in computation by the State of XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX

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[73] See State Rebuttal Testimony on Structural at 5. The State provided the initial velocity as XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX.

[74] See NRC Staff's Testimony of Gordon Bjorkman and Gustavo Aramayo Concerning the State of Utah's Analyses of the Consequences of an Accidental F-16 Aircraft Crash or Munitions Impact into a Hi-Storm 100 Storage Cask at the Proposed PFS Facility (July 12, 2004, as revised August 6, 2004) at 11 [hereinafter Staff Direct Testimony on Structural and Ordnance (Bjorkman and Aramayo)] .

[75] See id. 11-12. The practice bombs carried by the aircraft in question here, contain concrete powder designed to have the same weight and density as the explosive which would be contained in live ordnance.

[76] See Tr. at 17668-17675 (Bjorkman). The computer code used for these analyses requires the user to put its input in the form of "true stress strain" rather than engineering stress strain as the State had done (following the data supplied by the Applicant, see Tr. at 16895, 17672 (Bjorkman) in its initial analysis).

XXXXXX [77] XXXXXXXXXXXXXXXXXXXXXXXXX in the case of the use of the Staff's estimate of actual physical properties.[78]

But even in the analysis by the State with the "weaker" assumed steel properties, the ordnance was so slowed down by the energy loss XXXXXXXXXXXXXXXXXXXX [79] that the resulting computed maximum tensile strain in the MPC was approximately 4.3 percent.[80] Since it is clear that the XXXXXXXXXX actually carried by the aircraft in question are not rigid, and since it is clear that a "deformable" bomb XXXXXXXXXXX than a rigid bomb, we find that these computations indicate, with reasonable confidence, that the XXXXXXXXXXXXXXXXXX will, at the speeds used in these analyses, not penetrate the overpack and that damage, if any, to the MPC will result in maximum tensile strains well below the maximum of 10 percent indicated for full impact of an F-16 at the speeds and angles discussed above.[81]

With the evidence before us indicating that the maximum tensile strains in the MPC from the scenarios examined will not exceed 10 percent, we must then examine whether there is reasonable confidence that the MPC would, when subjected to such strains, retain its physical continuity and therefore its capacity to retain the fission products it contains.[82] The issue -- upon which this case turns -- devolves to identification of the appropriate method to determine the strain at which this particular stainless steel will fail in tension.

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[77] See Tr. at 19134 (Bjorkman).

[78] See Tr. at 17673-74 (Bjorkman).

[79] See Tr. at 19119 (Bjorkman).

[80] See Tr. at 19134 (Bjorkman), 19418-19 (Sozen acknowledging that, in terms of strain on the MPC, the Staff and State run are no different).

[81] See Tr. at 19460 (Bjorkman), 19504 (Hoffman), 19506 (Sozen).

[82] See Tr. at 15674-79. During the first days of hearing, the Applicant made clear that the design goal of the cask is to prevent a radiological release. Therefore, as long as the MPC is not breached, the cask has not failed. The Applicant noted that while it will develop a removal process to deal with the accident, it does not matter, for purposes of this proceeding, how damaged the cask becomes as long as the MPC does not rupture.

In this regard, the parties' approaches are diametrically opposed. The Applicant[83] and the Staff[84] argue that this must be addressed by examining actual known (measured) physical properties of the material at issue, focusing on the experimental evidence shedding light on the maximum true strain at tensile failure. The State argues, on the other hand, that civil engineering standards (including certain ones adopted by the U.S. Department of Energy for examination of the ability of certain nuclear structures to withstand aircraft impact) prescribe a defined maximum strain above which a component must be assumed to fail.[85]

Put another way, we are faced with the choice of examining the issue from basic materials principles or viewing it from the perspective of a civil/structural engineering problem. Although one might not expect these approaches to be mutually exclusive, they have been formulated just that way in this proceeding.[86]

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[83] See Applicant Direct Testimony on Structural at 2, 6-8; Rebuttal Testimony of Alan I. Soler and Charles J. McMahon, Jr. on the Structural Effects of a Potential F-16 Impact on a Spent Fuel Cask -- Contention Utah K/Confederated Tribes B (July 29, 2004) at 13 [hereinafter Applicant Rebuttal Testimony on Structural].

[84] See Staff Direct Testimony on Structural (Bjorkman, et al.) at 7-8; Staff Rebuttal Testimony on Structural (Bjorkman, et al.) at 4-5.

[85] See State Direct Testimony on Structural at 7-10.

[86] The following discussion relies heavily upon the ability of materials to withstand the application of tensile and compressive forces and the measures used to describe them among engineers. For the uninitiated, generally, when a force is applied to a material, its change in length (either stretching or compressing), which depends upon the force per unit area (defined as stress) is commonly discussed in terms of the engineering strain, which is computed by dividing the change in length (parallel to the applied force) by the original length. While strain is taking place, the cross sectional area actually changes (enlarging if the force is compressive and decreasing if the force is tensile).

Two common ways of describing the stress have evolved: "engineering stress," which is defined as the force divided by the unaltered cross sectional area; and "true stress," which is the force divided by the altered cross sectional area. However, while "engineering strain" is the change in length divided by the unaltered original length, "true strain" is defined as the natural log of the original cross sectional area divided by the altered cross sectional area. (NOTE that, since these are simply computations based upon measured force, length and area, the "engineering" stress and strain for a given condition can be mathematically converted to the

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The Applicant and the Staff propose that, once the experimental data is used to determine the actual tensile rupture strain, one should then apply a certain "safety factor" [87] (i.e., determine that the analytical result is acceptable only if the computed strain falls short of the experimentally determined failure strain by a multiple selected to give sufficient comfort that failure would not occur),[88] a common approach in engineering analysis. Such a "safety factor" would account for the fact that those properties are measured in quasi-static laboratory conditions (experimentally-determined information regarding dynamic loading is discussed below) on samples which have not been subjected to the variations which might be expected to occur in the manufacturing, construction and assembly process.

On the other hand, the State argues in essence that when this Stainless Steel is strained beyond approximately 2.5 percent true strain, it must, in accordance with customary civil

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[86](...continued)
"true" stress and strain for the same conditions by simply knowing the unaltered cross sectional area and length and the altered cross sectional area and length.)

Materials can be strained a small amount without undergoing permanent deformation -- such deformation being generally referred to as "elastic" strain, and the point at which the material begins to become permanently deformed being the "elastic limit." Once a material is strained beyond its elastic limit (that is, it will not return to its original dimensions once the stress ceases), it does not cease to offer resistance to further strain, and in fact, in some circumstances, its ability to resist further elongation actually increases. However, further strain becomes, at least in part, permanent, and is referred to as "plastic" strain. Some materials, like stainless steel, are able to undergo quite large plastic tensile strains before finally rupturing, and are sometimes referred to as being very "ductile."

[87] See Applicant Direct Testimony on Structural at 72-73; Applicant Exh. 293; Staff Direct Testimony on Structural and Ordnance (Bjorkman and Aramayo) at 27.

[88] See, e.g., Tr. at 15310-11 (Soler). In this regard, we note that the State's expert witness (Dr. Sozen) did not take issue with the principle that steels can be strained well beyond their elastic limit and well beyond the limit suggested by the civil engineering codes to which he refers for a failure criterion. He argued, instead, that there is increasing uncertainty in material behavior once the steel is strained beyond the threshold values he would suggest. Therefore, he suggests, one should, rather than beginning from the experimentally determined strain at failure and applying a safety factor, elect to assume that any strain beyond that determined using a ductility ratio specified for acceptable loads from a design perspective would cause failure in tension. Tr. at 16242-16244 (Sozen).

engineering principles, be assumed to fail.[89] The State's arguments rely heavily upon a standard developed by the Department of Energy[90] (hereinafter, the "**DOE Standard**") for application to assessment of structural integrity of nuclear facilities subjected to dynamic loading by aircraft impact -- an approach which on its face appears meritorious.

Upon closer examination, however, three things are clear: (1) the standard set forth in Table Q1.5.8.1 of the ANSI/AISC Standard and referenced in the DOE Standard is inapplicable, by its own terms, to "pressure vessels"[91] (and the Applicant and the Staff assert that the MPC is a "pressure vessel" rather than a structural member for purposes of assessment in accordance with the methodology referenced in the DOE Standard);[92] (2) the DOE standard was developed with a clear focus upon "structural" members, which are made of carbon steel, not stainless steel;[93] and (3) the DOE Standard was intended to be used as a tool to assess whether or not a particular structural member would fail to be able to continue to perform its structural function when subjected to the load at issue, not for use to assess the point at which a steel component

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[89] See Tr. at 16514-16 (Sozen).

[90] See State Exh. 254, United States Department of Energy Standard (DOE-STD-3014-96), Accident Analysis for Aircraft Crash into Hazardous Facilities (Oct. 1996); State Exh. 229, American National Standard Institute/American Institute of Steel Construction (ANSI/AISC) Standard N690, Specifications for the Design, Fabrication, and Erection of Steel Safety-Related Structures for Nuclear Facilities (1994) at 23, Table Q1.5.8.1, Allowable Local Ductility Factor, F, to be Used in Design of Steel Structural Elements for Impractive and Impulsive Loads (2002 Supplement) [hereinafter ANSI/AISC Standard]; see also State Direct Testimony on Structural at 8-9.

[91] See State Exh. 295, ANSI/AISC Standard at 23, Table Q1.5.8.1 (as referenced in State Exh. 254, DOE Standard at 76); see also Staff Exh. 103, AISC/ANSI Standard at Q1.01 (Scope); Staff Rebuttal Testimony on Structural (Bjorkman, et al.) at 5-6; Staff Rebuttal Testimony on Structural (Bjorkman/Aramayo) at 2.

[92] See Applicant Direct Testimony on Structural at 68-69; Applicant Rebuttal Testimony at 15-16; Tr. at 16810-11 (Bjorkman).

[93] See Applicant Rebuttal Testimony on Structural at 15-16; Staff Rebuttal Testimony on Structural (Bjorkman et al.) at 6; see also Applicant Rebuttal Testimony on Structural at 2,3,4,13-15 (noting differences between austenitic and ferritic steels).

would fail by stretching to the point that it ruptures (or that a hole was created in it as a result of the tensile loads).[94] The result is that, while the State's proposed standard (based upon use of a maximum "ductility ratio") is indisputedly applicable to determination of the failure point of the components of a structural steel member in a buckling mode,[95] it is unrelated to determination of the failure of a steel component by tensile rupture,[96] which is at issue here. We so find.

The experimental (laboratory) data presented to us indicates that this particular stainless steel can undergo approximately 90 percent true strain before it fails by rupture.[97] While the State did not dispute this data and information,[98] it argues that this laboratory data is inappropriate for use in these circumstances, and that "real life" stainless steel will have

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[94] See Applicant Rebuttal Testimony on Structural at 13-14; Tr. at 16937-38, 17041-48, 17079-80 (Bjorkman).

[95] See Tr. at 16834-43, 16937-38, 17041-49, 17081-82, 17202-03, 17250, 17279 (Bjorkman testimony asserting that the ductility ratio is used to compute buckling failure).

[96] The State's witness has neither presented nor pointed to a single piece of experimental evidence which would support the hypothesis that the steels at issue here would fail to retain their continuity (and therefore their confinement capability) or fail in tension by rupture at any strain nearly as low as the State proposes as a standard for judgement here. See also Tr. at 16839-42 (where Dr. Bjorkman further describes the technical article cited in reference 69 in the Staff Exh. 111, ANSI/AISC Standard at C-18, CQ.1.5.8). In that article, Dr. Bjorkman explains, the authors use the ductility ratio to assess structural failure by examining buckling, not rupture. Thus, Dr. Bjorkman continues, failure was determined by analyzing the point at which a structure ceases to be able to carry a load, buckles, and becomes unstable. Failure is not determined by analyzing the point at which a structure is ruptured. Id. at 16842.

[97] See Tr. at 16004-06 (Bjorkman); Staff Exh. 92, Structural Alloys Handbook (John M. Holt et al. eds., 1996 edition, v.2) at 45. According to Dr. Bjorkman, the Staff's search for material properties in common sourcebooks indicated that the 304 stainless steel's lowest data point value of true strain at rupture they found was approximately 92 percent. Tr. at 16006. See also Staff Exh. 93, The American Society for Metals International, Atlas of Stress-Strain Curves (2nd edition.) at 184 (graphing true-stress strain curve of 304 stainless steel and showing that at both elevated and room temperature, the true failure strains was greater than 90 percent); Staff Rebuttal Testimony on Structural and Ordnance (Bjorkman and Aramayo) at 9.

[98] See e.g, Tr. at 16495-99, 16505-16517 (where Dr. Sozen offered no support for a contrary view despite being afforded extensive opportunity); see also Tr. at 16257.

impurities and irregularities which would make it fail in tension at a materially lower true strain.[99] In support of this proposition, the State points to the fact that this material cannot be expected to be manufactured free of impurities and irregularities, and is welded in numerous locations, all of which (the State argues) would weaken the material.[100]

Although those propositions seem reasonable, the State neither submitted nor pointed to a single piece of experimental evidence supporting them.[101] And the Applicant (supported by the Staff) responded by pointing to the facts that: (a) the steel plates used to make up the MPC are manufactured, and examined during and after manufacture, to assure compliance with the ASME Code requirements for this material and this application, and that any plate failing to conform to those standards would be rejected from use;[102] and (b) the welds are performed in accordance with ASME prescribed and approved processes and procedures, and, since the ASME code requires that the weld material have identical strength to the base material, there is no basis for an argument that the weldment would represent a "weakness."[103]

To emphasize this point, the Applicant presented to the Board strained strips of actual weldment material taken from the stainless steel to be used in these MPCs.[104] These strips had been bent to nearly 180 degrees with no visible indication of rupture on the outer elements (which are the elements exposed to tensile strains in such a bend).[105] The Applicant's experts

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[99] See Tr. at 16243-44, 16514-16 (Sozen).

[100] See note 99, above.

[101] See e.g., 16516-17 (Sozen).

[102] See Applicant Direct Testimony on Structural at 69-73; Applicant Rebuttal Testimony on Structural at 5-6.

[103] See Applicant Direct Testimony on Structural at 7-8, 71-73; Applicant Rebuttal Testimony on Structural at 2-3; Tr. at 15242-44 (Soler), 15724-25 (McMahon).

[104] See Applicant Exh. 307 (physical specimen of ½ inch weldment bend test).

[105] See Tr. at 15239-40 (Soler).

indicated that the tensile strains in the outer elements of that strip would be in the order of 20 percent.[106] Similarly, the Staff's experts presented samples of deformed stainless steel exposed to very high loads in an experimental environment, and also demonstrated that this particular stainless steel withstood true strains of the order of 90 percent without tensile rupture.[107]

In addition, the State argued, without submittal of supporting experimental data, that the maximum strain at rupture in tension would be reduced when loads are applied rapidly.[108] The Staff's evidence, however, demonstrates that there is minimal effect on tensile rupture strain at the strain rates computed to occur in these crash events.[109]

Finally, the State argued -- for the first time -- in its rebuttal brief filed on November 22, 2004, that application of the ASME Code Appendix F criteria would indicate that maximum permissible strains under that code are less than 10 percent.[110] However, it is clear from both the State's analysis and the responses of the Staff[111] and the Applicant to the Board's

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[106] See Applicant Exh. 301, Bend Test of 304 SS; Tr. at 15240 (Soler).

[107] See Tr. at 15974-16002 (Kalan), 16010-11 (Bjorkman); see also Staff Exh. 107, (pulled steel).

[108] Tr. at 16243, 16524-25 (Sozen).

[109] See Tr. at 16004-10 (Bjorkman); Applicant Exh. 305, W. Lee et al., The Effects of Strain Rate and Welding Current Mode on the Dynamic Impact Behavior of Plasma-Arc-Welded 304L Stainless Steel Weldments, Metallurgical and Material Transactions A, vol.35A (May 2004) 1505; Staff Exh. 92, Structural Alloys Handbook at 45 (providing a table of strain rate effects and ductility); see also Tr. at 16000 (staff witness Dr. Kalan noting that stainless steel is not particularly strain rate sensitive).

[110] See State of Utah's Reply Findings of Fact and Conclusions of Law on the Phase II Hearing of Contention Utah K/Confederated Tribes B (Cask Breach Probability) (Nov. 19, 2004) at 15-25 [hereinafter State Reply Findings of November 19, 2004].

[111] In this opinion we do not rely on any material supplied by the Staff in the affidavit of Dr. Bjorkman attached to the "NRC Staff's Response to the Licensing Board's Order Directing Clarification of Record" (Dec. 16, 2004) [hereinafter Staff's Response of December 16, 2004]. Thus the Board, consistent with the State's position in the "State of Utah's Answer to the Board's Directive Re Clarification of the Record" (Dec. 21, 2004), did not ask for any further briefs from the State on this matter.

December 1 Order requesting clarification of the record,[112] that the State misapprehended the relevant ASME Code provisions, having applied a criterion established for examination of general primary membrane stress (or strain) which is applicable in circumstances where a member is globally (i.e., essentially uniformly) strained -- such as loading on a balloon by internal pressure.[113]

To explain further, the ASME Code expressly provides criteria for three types of loadings: general primary membrane stress (as discussed above); primary stress -- in which the stress is averaged through the wall thickness of a locally loaded (stressed/strained) region;[114] and local stresses.[115] Since the loadings which are created by the accidents at issue here are clearly not global, but are very localized, we find that application of general primary membrane stress/strain criteria would be incorrect. Furthermore, we find that Appendix F of the ASME Code would guide a user toward use of a localized stress and strain criterion such as has been developed by the Staff's expert, Dr. Bjorkman.[116]

Finally, although we do not endorse, as more fully discussed below, the concept of application of any Code-delineated prescriptive formula for determination of failure in this sort of examination, we note that even if the ASME Code's Appendix F criteria for primary stress/strain

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[112] See Staff Response of December 16, 2004; Applicant's Response to Board Order Directing Clarification of the Record (Dec. 16, 2004) [hereinafter Applicant's Response of December 16, 2004]; see also Order Directing Clarification of Record (Dec. 1, 2004).

[113] See State Reply Findings of November 19, 2004 at 15-16, 19; Applicant's Response of December 16, 2004 (Dec. 16, 2004) at 17-18.

[114] See Applicant's Response of December 16, 2004 at 21-22; Staff Response of December 16, 2004 at 4.

[115] See Staff Exh. 90, American Society of Mechanical Engineers (ASME), Boiler and Pressure Vessel Code: ASME an International Code, Rules for Construction of Nuclear Facility Components (2001) at Appendix F ¶ F-1341.2 (Plastic Analysis); see also Staff Response of December 16, 2004 at 4; Applicant's Response of December 16, 2004 at 21-22.

[116] See Staff Response of December 16, 2004 at 4-5; Staff Rebuttal Testimony on Structural and Ordnance (Bjorkman and Aramayo) at 7-8.

were applied (which, although the ASME Code would guide an analyst toward use of a purely local evaluation such as has been performed by the Staff, is clearly more applicable than the criterion for general primary membrane stress/strain), the maximum permissible tensile strain would be on the order of 25 percent,[117] well above the maximum of 10 percent computed by any of the three analyses at issue here, that the parties predict to result from a "bounding event" F-16 crash.

As we mentioned above, the fundamental issue underlying this portion of the argument is whether the "failure criterion" for the MPC should be based upon actual expected materials properties or upon the use of a formulaic standard used in civil or mechanical engineering.

We, therefore, do not find persuasive the arguments presented by the State that one should assume failure at a specific ductility ratio (which amounts to the prescriptive establishment of a defined maximum strain not based upon material properties and relatively invariant with choice of materials) or that one should apply a particular criterion suggested in the ASME Code. In this regard, the State's expert is a civil engineer experienced in structural design,[118] but has essentially no experience in (and is not an expert in) materials properties, the behavior of any steel under large strain conditions, or the behavior of stainless steels under the circumstances at issue.[119]

Nonetheless, while we are persuaded that the MPC's stainless steel can withstand, without tensile rupture failure, much more than the approximately 2.5 percent maximum strain which would be suggested by use of a ductility ratio as proposed by the State, and materially

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[117] See Applicant's Response of December 16, 2004 at 21.

[118] See State Direct Testimony on Structural at 1-3, Biographical Data: Mete A. Sozen; see also Tr. at 16289-92, 16523-24, 16528-29, 19531-32 (Sozen).

[119] See Tr. at 16289-93, 16300-01 (Sozen acknowledges that he is neither a mechanical engineer or a metallurgist, that he has seldom worked with stainless steel, and in fact, this hearing was the first time he has looked at stainless steel "intensely").

greater tensile strains than the approximately 10 percent indicated by all of the parties' computations, we also believe it would not be prudent to assume that the MPC could handle 90 percent true strain in tension before losing its integrity as might be suggested by the laboratory data. On this point, the Staff experts testified that application of an uncertainty factor of two or three to the laboratory data would both: (a) adequately accommodate the unknowns regarding the effects of manufacturing and assembly of the MPC; and (b) provide reasonable confidence that a conservative failure criterion was being used.[120] Therefore, given that the maximum computed true tensile strain in the MPC in all of these analyses is less than 10 percent, which is more than a factor of nine below the laboratory data, we find that there is reasonable confidence that the MPC would not fail under the conditions predicted by these analyses.

Based upon the foregoing, this Board accepts the principle put forth by the Applicant and supported by the Staff that the MPC will not fail when the overpack is impacted by an F-16 traveling at a speed equal to or less than XXXXXXXXXXXXXXXXXXXXXXX or more from the horizontal. We so find. Similarly, this Board finds that the MPC will not fail when the overpack is impacted by a XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX. The foregoing events, therefore, become the bounding events for use, after determination of the distribution of the probabilities of impact of an F-16 (or the XXXX ordnance) at various speeds and angles, in determining the UEP.

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[120] See Tr. at 15986-88 (Staff witness Dr. Gwinn commenting that 50 percent of the ultimate strain would be a reasonable "upper limit" to the strain to which a material should be subjected and that at 30 percent one would have "a comfort factor that is good"), 15995 (Gwinn again noting that going to half of the ultimate strain will account for any flaws, welds, or any other weaknesses in the material); see also Staff Rebuttal Testimony on Structural (Bjorkman/Aramoyo) at 4-5 (noting that the ASME Code allowable strain limit is 46 percent), 9 (noting 92 percent true rupture strain for 304 stainless steel). Such a "safety factor" would result in use of a "failure criterion" of approximately 45 percent true strain, a number completely consistent with the 46 percent criterion proposed by Staff expert Bjorkman. Id. at 4-5.

4. The Probability Analysis. The Applicant's structural analysis resulted in a bounding incoming F-16 flight at XXXXXXXXXXXXXXXXXXXXXXX,[121] while the State's computation assumed an impact speed of XXXXXXXXXXXXXXXXXXXXXXX.[122] Since neither computation reached the threshold strain in the MPC, we find that it is appropriate to use the larger set (bounded by the Applicant's bounding case which we have just approved) to determine the UEP. Thus we turn now to determination of the probability that a certain crash speed is below the bounding case, which will enable the determination of an upper bound on the UEP. To make this determination, we must look to the parties' analyses regarding what crash data should be included in making the computation.

There is limited data available regarding crashes of F-16 aircraft under conditions which are reasonably similar to those of Skull Valley. From crash data available from 121 accidents worldwide, the Applicant has identified 61 crashes which it believes are applicable and which were considered as "Skull Valley type incidents" by the prior Board.[123] Among those 61

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[121] See Applicant Exh. 265, Cornell Report at 23 (Dr. Cornell evaluated the impact on the cask at 40 inches below the lid); see also Testimony of C. Allin Cornell on the Unanalyzed Event Probability of Aircraft Crash or Jettisoned Ordnance Impacts at the PFSF -- Contention Utah K/Confederated Tribes B (July 12, 2004) at 16 [hereinafter Applicant Direct Testimony on Probability].

[122] See State of Utah Supplemental Testimony of Michael C. Thorne Ph.D for Contention Utah K/Confederated Tribes B Cask Breach Probability Proceeding (Sept. 9, 2004) at 2; see also State Exh. 238, M.C. Thorne, Ordnance Impacts and Aircraft Crashes at a Proposed Private Fuel Storage Facility for Spent Nuclear Fuel in Utah: Summary of Probability Estimates (May 2004) at 13 (setting forth four case scenarios for side and top cask impacts at varying speed and angles) [hereinafter Thorne report]. It was not until the Dr. Thorne's supplemental testimony, prepared at the request of the Licensing Board to address the issue of an appropriate flight data set, that the State set forth the boundary speed of XXXXXX cask side impacts.

[123] See Testimony of C. Allin Cornell, Wayne O. Jefferson, Jr. and Ronald E. Fly on the Appropriateness of Using Skull Valley Type Events for Evaluating the Speed and Angles of Potential F-16 Crashes in Skull Valley, Utah -- Contention Utah K/Confederated Tribes B (July 12, 2004) at 3 [hereinafter Applicant Direct Testimony on Speed and Angles].

incidents are four crashes which essentially occurred on runways.[124] In this proceeding, the Applicant eliminated from consideration the four incidents which were essentially runway incidents.[125] The Staff concurred with the Applicant that these remaining 57 incidents are those properly considered in development of the probability distributions.[126]

The State, on the other hand, argues that in addition to the four runway related accidents, 13 more incidents should be excluded, including nine loss of engine power incidents which occurred during take off and landing,[127] and four accidents that involved other situations

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[124] See id. at 5-6; see also Applicant Exh. 266, Maj. Gen. Wayne O. Jefferson, Jr. et al., Evaluation of F-16 Aircraft Crash Impact Speed and Angle for Skull Valley-Type Events (Rev. 1) (Jan. 2004) at 2, Tab A (Chronological Listing of Data from F-16 Mishap Reports FY89-FY98) [hereinafter Burdeshaw Report]. These are the incidents occurring on April 24, 1992; May 5, 1992; August 27, 1993; and March 30, 1994.

[125] See note 124, above [***discussing four excluded flights***].

[126] See NRC Staff's Testimony of Kazimieras M. Campe and Amitava Ghosh Concerning F-16 Crash Impact Speeds and Angles for Skull Valley Type Events (July 12, 2004, as revised Aug. 6, 2004) at 11-12 [hereinafter Staff Direct Testimony on Speed and Angles]; NRC Staff's Rebuttal Testimony of Kazimieras M. Campe and Amitava Ghosh Concerning F-16 Crash Impact Speeds and Angles (July 29, 2004 as revised August 20, 2004) at 2-3 [hereinafter Staff Rebuttal Testimony on Speed and Angles].

[127] See State of Utah's Testimony of Lt. Col. Hugh L. Horstman and Lt. Col. Luis N. McDonald III for Contention Utah K/Confederated Tribes B Cask Breach Probability Proceeding (Speeds and Angles Ordnance) (July 12, 2004) at 15 [hereinafter State Direct Testimony on Speed and Angles] at 15 (noting that while all nine accidents were caused by engine failure, they should be excluded because the flight characteristics, namely altitude and speed, could not occur over the PFS site because there are no runways for pilots to attempt to land or take-off). The nine excluded events include accidents on: August 7, 1990 (engine failure during pilot's landing approach); February 20, 1991 (engine failure as pilot attempted to reach a landing field); May 7, 1991 (engine failed 52 seconds after takeoff); June 8, 1991 (pilot attempted to land following engine failure); January 13, 1992 (pilot attempted to land following engine failure); September 18, 1992 (engine failed after pilot took off and raised landing gear); April 21, 1993 (pilot attempted to land following engine failure); July 11, 1996 (pilot attempted to land following engine failure); January 29, 1997 (pilot attempted to land following engine failure). Id. In proposing elimination of these accidents, the State argues that in an accident in Skull Valley over the PFS Facility, a pilot would not attempt to land in the event of an engine failure and would not delay an ejection (thus affecting the crash angle and speed) in an attempt to reach a runway. Similarly, the State argues, a pilot would not experience engine failure in Skull Valley at the low speed and altitude experienced immediately following take-off. Id.

that could not happen in Skull Valley.[128] Much of the testimony centered on which of those thirteen should be included,[129] and there was very little disagreement on the methodology which should be used to generate the probabilities once the proper data set was selected.

This question of whether or not the proper set of events is the 57 events proposed by the Applicant and the Staff or the 44 events proposed by the State has a relatively important effect upon the final probability distributions. In addition, it is clear that inclusion of irrelevant or unrepresentative data, or conversely, exclusion of relevant data, will corrupt the dataset and lead to misleading results, particularly where, as here, the size of the dataset is small. These issues are addressed below.

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[128] See State of Utah's Pre-filed Rebuttal Testimony of Lt. Col. Hugh L. Horstman (U.S.A.F. Retired) for Contention Utah K/Confederated Tribes B Cask Breach Probability Proceeding (Speed and Angles) (July 29, 2004) at 2-3 [hereinafter State Rebuttal Testimony on Speed and Angles]. These four accidents occurred on: October 22, 1992 (altitude decreased when pilot delayed ejection in an attempt to make emergency landing at an air force base); October 25, 1994 (pilot ejected below minimum ejection altitude after attempting to land on runway); August 11, 1993 (pilot delayed ejection to crash on an island instead of over open ocean); July 1, 1994 (initiating event was caused by a bird and the Board ruled in LBP-03-04, 57 NRC at 168, that a bird strike in unlikely in Skull Valley).

[129] The Applicant's witness, Dr. Cornell, argued that the four runway events should obviously be excluded because they include no impact information, speeds, or angles. The remaining flights, however, all provide useful information and data should not be weighted or excluded based on altitude because the probability of a crash exceeding XXXXXX is insensitive to such adjustments. See Tr. at 17738-42. While the State witness, Lt. Col. Horstman, agrees that the four runway events should be excluded, he also argues that an additional 13 events (discussed above) should be excluded because the accident crashes could not occur at the PFS site and including them in the data set lowers the impact speed estimation at the PFS site. See State Direct Testimony on Speed and Angles at 14-15; State Rebuttal Testimony on Speed and Angles at 2. Furthermore, Lt. Col. Horstman argues, the Applicant's rationale to exclude the four runway related accidents, but not the nine accidents that occurred while a pilot was attempting to land on, or take-off from a runway, is inconsistent. Id.

For its part, the Staff, in analyzing the 13 additional events, concluded that while 3 of the 13 (the accidents of April 21, 1993; January 13, 1992; and September 18, 1992) accidents occurred in such close proximity to the runway that they might not be representative of Skull Valley flight conditions, the specific flights parameters are possible in Skull Valley and thus they should not be excluded. See Staff Rebuttal Testimony on Speed and Angle at 5. The remaining accidents, the Staff concluded, occurred under flight conditions comparable to those that could occur in Skull Valley regardless of whether the accident occurred during landing or take off. See id. at 2-7.

Before examining the particulars of each incident to identify those incidents which are properly included in this analysis, we focus upon determining which incidents provide useful information. The technical approach taken by the parties was to examine the incidents for which there is crash impact data to determine if any reasonable correlation could be made between the flight conditions at onset of the incident and the crash speed and angle which must be determined for use in the analyses at hand.

There are only fourteen accidents for which the ejection speed and altitude and the crash impact speed are all reasonably known.[130] The Applicant's and Staff's analysts used regression analysis to develop from those few incidents a correlation between ejection speed and altitude and the measured speed of impact.[131] Then, from applying that regression analysis, the Applicant and Staff each developed a methodology to expand the data set, using the correlation to estimate the "missing" information for the accidents where only partial information was available.

In an effort to determine whether accurate results could be obtained using only accidents containing complete data, the Board asked the Applicant to examine the probability distribution based only on incidents with known data and to weight those according to the relative frequency of flights in the two flight ranges, known as Sevier B (3000 ft to 4000 ft above ground level ("AGL")) and Sevier D (approximately 5000 ft AGL to 14,000 ft AGL).[132] In response, the Applicant examined accidents with documented impact speeds and found a dataset of 15

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[130] See Applicant Exh. 266, Burdeshaw Report at 10, Tab G.

[131] See Applicant Exh. 266, Burdeshaw Report at 4, 10-11; Tr. at 17753 (Cornell), 17758 (Fly); Staff Exh. 100, Dr. Kazimieras M. Campe and Dr. Amitava Ghosh, NRC Staff's "Evaluation of Aircraft Crash Impact Speeds and Angles considered by Private Fuels Storage, L.L.C. in its Analyses of Skull Valley Type Events (May 24, 2004) at 14 [hereinafter Staff Evaluation of Speed and Angles]; Tr. at 18051-52 (Campe).

[132] See Tr. at 17924 (Farrar).

accidents.[133] Of those 15 incidents,[134] nine originated within Sevier B and six within Sevier D.[135] Because Sevier B is weighted[136] so heavily, however, the nine events originating in Sevier B become the most relevant in considering the estimated probability that a future Skull Valley event would exceed XXXXXX.[137] Thus, the effective sample size is diminished from 15 to nine data points. Attempts to develop probability distributions of impact speed from those nine data points resulted in a projection with a standard error of estimation that is effectively 50 percent of the estimate and whose one-sigma error was the entire width of the projected impact speeds.[138]

Therefore, since a correlation based upon the nine incidents would be so unreliable, the Applicant and the Staff took a different approach to maximize use of all available data, ultimately resulting in use of the entire set of 57 Skull Valley-Type accidents to perform the analyses that

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[133] See Tr. at 17922-46 (Board and parties discussing assignment).

[134] See State Exh. 278 (Cornell "homework assignment" performed at the request of the Board, Tr. at 17922-26) at 2 [hereinafter Cornell Assignment].

[135] See Tr. at 18074-75 (Cornell); State Exh. 278, Cornell Assignment at 2. In the "homework assignment" given to Dr. Cornell, the Board asked him to exclude accidents that occurred above Sevier D and below Sevier B, thus excluding the two high ejection points referred to above and the four take/off and landing incidents because they are not representative of what might happen in Skull Valley. Though the Board asked the Applicant to include only those accidents with documented speed and angles within Seviers B and D, the Applicant examined only the accidents with documented speeds. As the State points out during cross examination, however, four of the accidents included in the dataset had speeds that were estimated by the Applicant. Tr. at 18075-76.

[136] See Tr. at 17737- 41 (Dr. Cornell explaining the methodology that went into weighing the data to account for the majority of Skull Valley flights occurring in Sevier B). Dr. Cornell has weighted Sevier B at 96 percent and Sevier D at 4 percent based upon the relative frequency of flights in those height sectors.

[137] Tr. at 18081-82 (Cornell)

[138] Tr. at 18082 (Cornell). It is well known that the standard error of an estimate is dependent upon sample size alone, and that as data sets become larger, the standard error becomes smaller.

lead to the probabilities of crash impacts at various speeds.[139] The Staff's experts concurred in the validity of use of all 57 incidents and confirmed the accuracy of the Applicant's correlation,[140] which led to being able to "fit" each actually measured impact speed to within 20 knots.[141] Experts representing the Applicant, the Staff, and the State all testified that the correlations of impact speed to ejection altitude and speed is robust (i.e., a good correlation with small error) for these larger data sets.[142] The Applicant and the Staff agree that in 18 cases, there is reasonably reliable data regarding the altitude and speed at which the pilot ejected from the aircraft, and the Applicant and the Staff argue that this entire set should be used, together with the 14 incidents where impact speed was known along with the ejection altitude and speed, to develop the probability of impact at various speeds.[143]

In addition to the information added to the dataset by inclusion of these events through statistical analysis, there is some logic to their inclusion because, for the incidents in question that are initiated by a loss of engine power, the flight path after engine failure can be predicted with some reliability. This is, because, as all parties' experts testified, the pilot would be

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[139] See Tr. at 18085 (Cornell explaining that limiting the data to documented speeds discarded about two-thirds of relevant accident data), 18698 (Cornell explaining that he used the entire data set in his regression analysis to establish impact speed).

[140] See Tr. at 18795 (Ghosh), 17969-71 (Campe, Ghosh); see also Staff Exh. 119, NRC Staff's Response to the Atomic Safety and Licensing Board's Questions Concerning the Probability of an Accidental F-16 Crash into the PFS Facility at 4-5.

[141] See Tr. at 17902-03, 18088-18091 (Cornell discussing the 20 knot standard deviation), 17872-73, 17893 (Applicant witnesses Fly and Jefferson discussing use of all 57 data points to establish correlation). While this did not lead to a perfect "fit", it led to a correlation coefficient very close to 1.0. See Tr. at 17853 (Cornell stating that the confidence bounds in the regression analyses was in the order of 95 percent); Applicant Exh. 266, Burdeshaw Report at 10-11, Tab G.

[142] See Tr. at 17753 (Cornell),17758 (Fly), 17969-71 (Campe, Ghosh), 18911 (Thorne).

[143] See Applicant Exh. 266, Burdeshaw Report at 10-11, Tab H; Staff Exh.100, Staff Evaluation of Speeds and Angles at 4 (18 incidents where ejection altitude and ejection speed were known).

generally expected, in the case of engine failure, to attempt to gain the maximum possible altitude (to provide the maximum amount of time to attempt to restart the engine) while not letting airspeed go below 250 knots.[144] With the loss of engine propulsion, the aircraft would then reach a peak in its trajectory and begin descent at approximately 220 knots.[145] Thus, it is reasonable to expect, in cases of engine failure (absent other malfunctions), that the aircraft will begin its descent at 220 knots. The testimony is uncontroverted that the aircraft's control systems will thereafter attempt to maintain that speed and maintain the descent at approximately 6 degrees below the horizon (through manipulation of the aircraft's flight control surfaces).[146] Pilots are advised to eject from the aircraft at no less than 2000 ft AGL, although there was considerable evidence in prior hearings that pilots in fact often stay with their craft below that altitude in their efforts to restart the engine and save the craft.[147] In fact, 52 of the 57 incidents being considered by the parties in these analyses were loss-of-engine accidents,[148] and 32 of those 52 had crash speeds of less than 250 mph.[149] This indicates that the majority of the loss-of-engine accidents indeed crashed at speeds not much faster than would be expected if all procedures were followed and aircraft controls operated as described. Of course, conversely, a large portion of such accidents did not exhibit that predictability. Nonetheless, it is clear to us that, in addition to the mathematical and statistical arguments for expansion of the dataset by

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[144] See LBP-03-4, 57 NRC at 171-72; State Direct Testimony on Speed and Angles at 7-8, 18; Applicant Direct Testimony on Speed and Angles at 4-5; Tr. at 17745-47 (Fly), 17997-98 (Campe).

[145] See LBP-03-04, 57 NRC at 172.

[146] See State Direct Testimony on Speed and Angles at 8, 18; Tr. at 17746 (Fly)

[147] See LBP-03-04, 57 NRC at 172; Tr. at 17805-06 (Fly).

[148] See Applicant Exh. 265, Cornell Report, App. A. Analysis of F-16 Crash Impact Speed and Angle Distributions (Rev. 1) at 4,5.

[149] See State Exh. 238, Thorne Report at Attach. 1.

inclusion of these additional incidents, there is a phenomenological basis for incorporating them as well, albeit with some caution as to actual speeds.

Two accidents involving initiating events other than engine failure resulted in pilot ejection above the top of Sevier D, and the State would have us rule that because no aircraft flying through Skull Valley would be traveling at those altitudes, these incidents should be excluded.[150] We see no reason, however, to exclude such incidents from the dataset simply because they originated at a particularly high altitude, since they do represent accident initiators which could take place at Skull Valley and thus should not be ignored.

The foregoing analyses raise the question, addressed below, regarding whether, and if so how, this Board should incorporate into its analysis the fact that approximately 90 percent of the 57 incidents being considered were initiated by loss of engine power.[151]

A similar issue is raised by a second set of incidents -- those which involve events that result in aircraft descending in a "deep stall." There were six incidents (i.e., approximately 10 percent of all incidents being considered) for which observers described the aircraft as "falling like a leaf;" in airframe vernacular, this is more accurately described as in a "deep stall," which means the descent is essentially vertical while the aircraft wings and fuselage remain essentially level with the horizon.[152] In those incidents, the aircraft manufacturer has advised the Staff that

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[150] See Tr. at 18389-90 (State witness Horstman explaining exclusion of the two flights); State Exh. 238, Thorne Report at Attach. 1 (excluding flight number 8, January 13, 1991, and number 33, September 11, 1993).

[151] Applicant Direct Testimony on Speed and Angles at 6; Applicant Exh. 265, Cornell Report , Analysis of F-16 Crash Impact Speed and Angle Distributions at 4-5.

[152] See Applicant Exh. 266, Burdeshaw Report at 4, 11, Tab I. The six deep stall accidents were as follows: January 13, 1991 (hydraulic failure and subsequent flat spin); March 19, 1991 (hydraulic failure, uncommanded barrel rolls); February 19, 1993 (uncommanded climb, aircraft rolling); September 11, 1993 (explosion, fire); June 25, 1995 (stall, fire, and explosion on impact); September 16, 1997 (mid-air collision followed by loss of control); Tr. 17811 (Fly).

the descent speed will be no more than 150 knots[153] and the Air Force believes that the descent speed will be between 99 and 148 knots.[154]

Accordingly, although the impact speed of those crashes is not known by any physical measurements, there is good confidence that impact speed for those incidents has an upper bound of 150 mph. We note that the Applicant used an impact speed of 123 knots for its probability computations,[155] which is the average of the range given by the Air Force, while the Staff, in its confirmatory analysis, used the upper bound speed of 150 knots.[156] For these incidents, the trajectory and impact speed are reasonably computable based solely upon the initiating cause of the accident.

Thus, there emerge two fundamental questions regarding how to approach this data: (1) should the data be limited in some fashion; and (2) in determining what circumstances are relevant for the instant case, should the crash data be examined and utilized from the perspective of how the incidents are initiated, independent of their originating altitude (i.e., if 90 percent of the relevant incidents are already determined to be initiated from engine failure and 10 percent initiated from causes which resulted in the aircraft descending in a deep stall, should the probability of a crash initiating from those conditions be 90 percent and 10 percent respectively and, based upon that, should crash angles and speeds for that 90 percent and 10 percent be determined expressly from those two specific types of incidents?

Our examination of the crash data makes it clear that those incidents which originated from engine failure cannot ALL be presumed to crash at the speeds and angles which would be predicted assuming aircraft controls actually managed the flight until crash. There is every

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[153] See Staff Direct Testimony on Speed and Angles at 7, 10.

[154] Applicant Testimony on Speed and Angles at 17.

[155] See Tr. at 17922 (Fly); Applicant Exh. 266, Burdeshaw Report at Tab I.

[156] See Staff Direct Testimony on Speed and Angles at 7.

indication, however, that all deep stall crashes had essentially the same crash flight path (wings level with a vertical descent) and crashed at speeds below 150 mph. Upon inquiry by the Board of the Applicant, Staff and State experts,[157] it was clear that none had analyzed the data from the perspective of initiating event, although all had examined the data from the perspective of flight conditions at incident initiation and at pilot ejection.

The Applicant[158] and the Staff[159] experts testified that, because the correlation of measured impact speed to ejection parameters was so good (robust), the proper approach to development of a formula which would predict impact speed from ejection parameters would be to use a correlation developed from the fourteen accidents to analyze the entire set of data points for which ejection parameters are known (consisting of 26 data points)[160] and use a regression analysis to develop (using the correlation based upon the 14 incidents discussed above) predicted impact speeds for all events in that set of 40 accidents.[161] Based upon that analysis, probabilities of impact speed were developed for the entire data set of 57 accidents.[162]

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[157] State expert Thorne confirmed that this would be a useful approach (Tr. at 18946-48), while PFS expert Cornell declined to comment (Tr. at 19035-36, 19044), although neither had examined it.

[158] See Tr. at 17743-44 (Fly, Cornell), 17753 (Cornell), 17758 (Fly).

[159] See Tr. at 18911 (Thorne).

[160] See Staff Exh. 100, Staff Evaluation of Speed and Angles at 4,5. The Staff details 18 accidents with known ejection altitudes and speeds, but unknown impact speeds; 7 accidents that document only ejection altitude, and one accident that documents only ejection speed, therefore totaling 26 incidents where ejection parameters are known. See also Applicant Exh. 266, Burdeshaw Report at 8-11.

[161] See Applicant Exh. 266, Burdeshaw Report at 10-11, Tab D, F, G, H.

[162] The parties excluded predicting impact speeds for the four runway related accidents. See Applicant Exh. 266, Burdeshaw Report at 14 n. 19. The primary reason for developing impact speeds for the entire data set is that expansion of the impact speed data set materially increases the breadth of data and a larger data set significantly improves the usefulness of the Cumulative Distribution Function (CDF) and the Complimentary Cumulative Distribution Function (CCDF), which are both needed in assessment of the UEP. See, e.g., Tr. at 18086 (Cornell notes that smaller data sets produce highly uncertain results), 17926-28, 18085-86 (Cornell noting the importance of using all the useful data), 18901 (Thorne).

When examined on the technical validity of that approach, experts for both the Applicant[163] and the Staff[164] took the position that, because these 26 additional incidents represent the available real data on crashes for F-16s, to ignore the information content of any particular incident without sound reason would create an inaccurate subset of the data. Therefore, they argued, since the ejection parameters are known and since there is such a good correlation between ejection parameters and crash impact speed, it is proper statistical methodology to compute impact speeds for the incidents wherein it was not measured. Thus they used the correlation for impact speed from ejection parameters based upon the fourteen incidents to develop (using a regression analysis technique which is itself unchallenged)[165] a set of formulae to compute impact speeds for the balance of the 26 incidents for which the impact speed was not known but ejection parameters were known.

The foregoing approach has merit: given that the correlation developed by the Applicant and confirmed by the Staff was so good for those data points where crash impact speed was measured,[166] and since the ejection parameters are known for a number of other data points, it

[163] See Tr. at 17926-28, 18085-86 (Cornell explaining why it is important to use all the data).

[164] See Tr. at 18015-17 (Campe and Ghosh noting that a small sample size introduces error).

[165] Although a State witness, Lt. Horstman, had some criticism that estimating impact speed and angles was too speculative (See State Exh. 242, Lt. Col. Hugh L. Horstman, Evaluation of Impact Velocity and Impact Angle for F-16 Crashes at the Proposed PFS Site (Sept. 2003), at 6-7), the State nonetheless relied on regression analysis during the hearing (see, e.g., State Exh. 279, M.C. Thorne, Ordnance Impacts and Aircraft Crashes at a Proposed Private Fuel Storage Facility for Spent Nuclear Fuel in Utah: Supplementary Analysis of Probability Estimates (Sept. 2004) at 10-11; Tr. at 18889 (Thorne); Applicant Exh. 284, Excerpts from Lt. Horstman's Deposition of May 24, 2004 at 159-60 (stating the Applicant's estimates appear to be relatively accurate).

[166] As is mentioned above, our confidence in that approach is in part improved by the fact that one would expect, from the standard post-engine-failure procedures that are followed, such a correlation to exist (and the data bears out this perception) for those incidents where the cause was solely loss of engine power (which represented a larger portion of the incidents under consideration).

is reasonable to utilize the correlation to develop projected crash speeds for those other data points. This enables the utilization of all the relevant information from ALL data for which ejection parameters are known to develop a probability distribution function for crash speed based upon all the available relevant data. We adopt that approach.

Unfortunately, no success was achieved in attempting to correlate the ejection parameters to the impact angle.[167] Thus, the data could not be expanded as to this parameter.

Turning now to those incidents whose applicability to the situation in hand is in question, we examine first those incidents where the pilot was attempting to find an airfield to land. Testimony provides the following relevant information:

(a) since these incidents resulted in crashes short of the landing area, the pilot may have been attempting to "stretch" the glide path. The State's expert testified that, although trained to use the fact that the maximum range would be achieved by a descent at approximately 6 degrees at airspeed of about 220 knots,[168] a pilot's instinct is to pull the nose up in a misplaced effort to "stretch" the glide path, but in fact such action results in reduction of airspeed and reduction of glide range.[169] The Applicant's experts testified that a pilot would not contradict that guidance,[170] but there appears to be no evidence to support a conclusion either way regarding pilot actions in any of such incidents included in this data set;[171] and

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[167] See Applicant Exh. 266, Burdeshaw Report at 3; Tr. at 17758 (Fly).

[168] There was no disagreement on this basic principle, just disagreement regarding how the pilot would react to the circumstances.

[169] See Tr. at 18419-22 (Horstman).

[170] See Tr. at 18511-13 (Fly explaining that the F-16 flight manual instructs that in attempting a flame out (i.e., loss of engine) landing, maximum glide range is achieved at seven degree angle of attack). Col. Fly further explains that if the pilot attempted to change his angle of attack, he would make his glide shorter, and that he would expect a pilot to follow the flight manual instructions. Tr. at 18517.

[171] See Tr. at 18511-13, 18529 (Fly further explaining how changing the angle of attack from the maximum glide path will shorten the glide range), 18418-22 (Horstman describing how (continued...)

(b) since reconfiguring the plane for landing (lowering landing gear, flaps etc.) substantially reduces airspeed and range, a pilot attempting to "stretch" his range would not reconfigure for landing until becoming certain of being able to land.[172] We were advised that landing gear can be lowered in approximately two seconds,[173] and therefore there is a reasonable probability, in incidents where the plane crashes materially short of a landing strip, that the plane would not have been "reconfigured" and would, instead, have been continuing its glide at approximately 6 degrees and would have crashed in the same mode as if the pilot had not been attempting to reach an airfield.[174] In incidents where the plane crashed near a runway, there is some likelihood that the pilot may have slowed the craft by instinctively raising the nose.

Thus inclusion of these data points in development of a correlation or in development of crash data must be selectively done. We find that inclusion of crashes occurring well short of a runway which have been categorized as "landing" incidents and which were initiated by loss of engine power are properly included because the crash characteristics would be expected to be substantially the same as a crash where the pilot was not attempting to land, even where the crash impact speed must be computed from the correlation described above. Crashes

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[171](...continued)
a pilot attempting to land may nonetheless think that pulling up the nose as he approaches the runway will extend the glide). The Applicant's and the State's witness also had some disagreement as to how to characterize several flights in the record, thus increasing the uncertainty in predicting how pilots will react in such circumstances. See Tr. at 17779-82 (Fly disagreeing with State's characterization of several accidents as "landing accidents" where the pilot lifted the nose of the plane because he believes that the pilots never intended to land the plane, but were instead lifting the nose of the plane to gain some altitude before ejection, something he describes as a perfectly acceptable flying procedure), 17791, 17794 (Fly noting a pilot may lift the nose of the plane up to increase the safety margin during an ejection).

[172] See Tr. at 18399-400 (Horstman), 18525-26, 18527-18529 (Fly).

[173] See Tr. at 18529 (Fly)

[174] See Tr. at 18404-05, 18451-52 (noting computer's involvement in impact angle).

occurring near a runway are, however, not properly included for two reasons: (a) there is no runway on or very near the PFS site, and therefore no F-16 could be expected to be attempting to land near the PFS site,[175] and (b) there is a reasonable probability that the pilot interfered with the electro-mechanically controlled glide path in an attempt to "stretch" his glide, thereby making the correlation inapplicable to determination of crash speed for such an incident. Similarly, take-off incidents in which the aircraft lost power before it reached the 250 knots target for the initiating conditions for a glide should be excluded. This reasoning calls for elimination of four of the 61 incidents (the four eliminated by all parties) reducing the applicable set to 57.

Considering now those six impacts which arose out of a descent in a deep stall, we note that the State would have us exclude the two deep stall incidents which were initiated above the highest customary flight path (i.e., above the upper extremity of Sevier D).[176] Their rationale is that since flights at such height will not occur in Skull Valley, those incidents are irrelevant.

This forces this Board to consider whether the data should have been partitioned by initiating event and analyzed on that basis -- a step not employed by any party, but nonetheless agreed by them to be a sensible one. As we noted earlier, of the 61 incidents considered by the prior Board to be relevant, six (approximately 10 percent) were incidents in which the aircraft fell in a deep stall.[177] This information is no less valuable than the distribution of incidents by ejection altitude and/or speed. Furthermore, as with the crashes where the parties predict

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[175] As discussed in note 196 below, pilots will not attempt to land F-16's on unprepared surfaces because the planes are too fragile.

[176] See Tr. at 18389-390 (noting State seeks to exclude the flights of January 13, 1991 and September 11, 1993); see also State Exh. 238, Thorne Report at Attach. 1 (excluding accident number 8 and 33 from the relevant data set). The State argues that because the initiating event and the ejection altitude in these two instances occurred above Sevier D they should be excluded from the data set because the crash could not reasonably occur in Skull Valley.

[177] See note 152, above.

impact speed from the ejection parameters, for these deep stall incidents one can predict impact speed within a very narrow range.

Thus, where the relevant crash data indicates that 10 percent are crashes in a deep stall and 90 percent originate from engine failure, it appears to us that it might be manifest error to assume that the same percentages should not apply to crashes originating from flights through Skull Valley.[178] Therefore, although we do not advocate reanalyzing all this data to develop such an approach, the fact that relevant crash data includes incidents initiating at altitudes outside the ranges expected to be flown by the F-16s flying through Skull Valley does not imply that one should not expect approximately 10 percent of the crashes in Skull Valley to also be deep stall type crashes.[179] In fact, we find that it implies quite the opposite. Therefore, we see no basis to eliminate the two deep stall events from use in developing the probabilities simply because they originated at altitudes not flown in Skull Valley. We are, therefore, not persuaded by the State's arguments that the two deep stall incidents which initiated above Sevier D should be excluded and we find, instead, that those two events are properly included in the computations.

Having thus determined which of the 61 accidents should properly be included in the computation of probability, we can now turn to examination of the probability that the aircraft will

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[178] Even the State's expert concurred that this was useful information which should be considered. See Tr. at 18947-48,18951-52 (Thorne).

[179] One could, following this logic, take the view that the relevant crash data informs us that 10 percent (6 of 57) of crashes are deep stall crashes which impact at 150 mph or less and 56 percent (32 of 57) are loss-of-engine power crashes which impact at less than 250 mph because they follow the expected glide path (because the procedures were followed and automatic controls functioned as expected and no other factors intervened). Based on this approach, one would conclude that the data advises that approximately two-thirds of crashes occur at less than 250 mph. This number is consistent with the complex statistical analyses performed by the parties which indicated that the probability of a crash at more than 250 mph is approximately 0.35 (see Applicant Exh. 265, Cornell Report at Fig A-1) and that the probability of a crash at more than XXXXX must therefore be materially smaller. In fact, it appears to us to be quite consistent with the Applicant's computed probability of approximately 0.20 for a crash at greater than XXXXXX. Ibid. Thus this simpler view of the information provided in the accident data (based upon more fundamental principles) gives us confidence that the Applicant's (and the Staff's) computations are reasonable estimates.

impact at angles and speeds above the bounding event (the UEP). The way the hearing developed, this particular computation has been performed for the event which this Board has determined to be the bounding event by the Applicant (and confirmed by the Staff), and has not been performed by the State.

The State's expert has, however, raised a challenge to the methodology which the Applicant and the Staff used to derive their probabilities, arguing that a correlation (which is essentially a "curve fit" to the data) has no particular basis and proposing, instead, to use a "step function" to describe the probability distribution.[180] The State's expert proposes a step function which results in zero probability for any accident whose impact speed is below the first data point,[181] holds constant at the computed probability of the first data point until the speed of impact reaches the second data point, holding constant at the probability of the second data point until the speed reaches that of the third crash data point, and on through the data.[182]

This particular choice of step function has the effect of shifting the probabilities toward higher crash impact speeds when compared to any other option one could chose (such as the "curve fit," or a linear interpolation, or a step function which assumes the probability is equal to the probability of first data point until the crash speed of the lowest impact speed is reached and then jumps to the second step until the speed of the second data point is reached).[183] Because there is so little data at higher crash speeds, such an approach has a material (but not dominating) effect on the Cumulative Distribution Function (CDF) and the Complementary

[180] See Tr. at 18876 -81 (Thorne).

[181] See Tr. at 18881 (Thorne's model has zero probability for any event less than 179 KTAS).

[182] See Tr. at 18870-71 (Thorne).

[183] See Tr. at 18879 (Thorne).

Cumulative Distribution Function (CCDF) and therefore upon the UEP. The State's expert has clearly demonstrated this effect for higher impact speeds.[184]

Upon examination, the State's expert offered no particular technical or scientific justification for why the step function could not have been such that the probability holds constant at the first value from zero speed up to the crash speed of the first data point then jumps to the second value rather than the steps which he employed.[185] In any event, we find it illogical to assume that probabilities would stay constant between data points as they do in either version of the step function. In that regard, we were presented with (and see) no particular reason why, for example, a linear interpolation between data points would not be a better correlation than the step function approach, and that there is no sound rationale for the election to use any particular type of step function.

In the final analysis, we recognize that we have before us sparse data that may be of questionable utility in predicting any particular incident. But, we see no reason to believe that the universe of possible incidents is properly represented by a discontinuous rather than a continuous function.[186] This does, however, raise a particularly important point for this Board. <u>If, as the testimony indicates, the computed probability of the UEP is materially sensitive to the methodology used to "fit" these sparse data, we must exercise caution in interpreting the results</u>.

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[184] <u>See</u> Tr. at 18868-70 (Thorne); State Exh. 285, Additional Probability Analysis at 5. State Exh. 285 indicates that using the step function Thorne proposed, when coupled with his proposal to reduce the dataset to 44 incidents, would increase the probability of breach from side impact from 3.75×10^{-7} to 5.06×10^{-7}. However, Dr Thorne indicated that the dominant cause for this increase was the elimination of 13 "take-off and landing" incidents from consideration. <u>See</u> Tr. at 18868-69, 18907.

[185] <u>See</u> Tr. at 18879-82 (Thorne).

[186] While this Board takes judicial notice of quantum mechanical principles, the discretization of energy and other properties characteristic of those principles do not manifest themselves on such a macroscopic level as those at issue here. Therefore, for the resultant probabilities to be quantized as the State's expert suggests would, we expect, imply a first-of-its kind phenomenon and form the basis for an entirely new field of study.

In this instance, the Applicant's computation (confirmed by the Staff) -- using the regression analysis to "fit" the data with a continuous "best fit" function (which is an accepted approach to interpretation of data) -- yields a total of 7.37×10^{-7} UEP.[187] While there is no dispute by the State's expert regarding the regression analysis methodology used by the Applicant and the Staff, the State's expert obtained a larger overall UEP as a result of selecting the worst case methodology for "fitting" the data by using a (discontinuous) step function and reducing the dataset by elimination of the 13 "take-off and landing" accidents and consideration of only 36 crash events.[188] Although not directly addressing the overall UEP, the State's expert pointed out that this approach leads to a probability of breaching the cask due to a top or side impact of 5.08×10^{-7} (as compared with 3.75×10^{-7} computed by the Applicant using the entire 57 accident dataset and a smooth curve fit to the data).[189] Although we find that there is no particular justification for use of the State's "worst case" analytical methodology, the State's computation emphasizes the fact that use of sparse data, and questions regarding determination of which events to include in performing analysis, can lead to results which one may question.

5. The Ultimate Question. The resultant UEP which would be computed from the Applicant's analysis leads to a 7.37×10^{-7} overall probability of an F-16 breaching a cask.[190] In contrast, the State has proposed between 2.0×10^{-6} and 4.08×10^{-6} as the probability range.[191]

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[187] See Applicant Direct Testimony on Probability at 9-10, 21-22; Applicant Exh. 265, Cornell Report at 51; NRC Staff Direct Testimony of Dr. Dennis R. Damon Concerning Aircraft Crash Probability Assessment (July 12, 2004, as revised Sept. 10, 2004) at 4 [hereinafter Staff Direct Testimony on Probability]; Staff Exh. 102, Dennis R. Damon, NRC Staff's Evaluation of Private Fuel Storage, L.L.C. Aircraft Crash Probability Assessment (May 11, 2004, as revised Sept. 10, 2004) at 16.

[188] See Tr. at 18868-73 (Thorne).

[189] See Applicant Exh. 265, Cornell Report at 48.

[190] See Applicant Direct Testimony on Probability at 21-22; Applicant Exh. 265, Cornell Report at 51.

[191] See State Exh. 238, Thorne Report at 21.

In considering the State's proposal, we note that since approximately two-thirds of all historic crashes occur at 250 mph or less (see note 179, above), no more than approximately one-third of the crashes being examined can be expected to be at speeds greater than 250 mph. Even if we were to assume that all impacts at 250 mph or above breached a cask (a hypothesis which is exceedingly conservative given the analyses of crash impacts discussed earlier), the overall UEP would thus be $0.333 \times (4.29 \times 10^{-6})$; in other words, the UEP cannot reasonably be expected to exceed 1.5×10^{-6}. Thus, we cannot give credence to the State's proposed range of UEPs: since one would expect a not-immaterial percentage of crashes to occur between 250 mph and the bounding case of XXXXXX for which non-breach has been demonstrated, even a very simplistic view of these events advises clearly that the UEP must be materially less than 1.5×10^{-6}.

On the other hand, the State's conservative analysis of breach probabilities would increase the Applicant's number by approximately 0.13×10^{-6} (based upon the increase from 3.75×10^{-6} to 5.08×10^{-6} discussed above), resulting in a UEP of approximately 8.7×10^{-7}. Therefore we see no credible argument for the position that the UEP exceeds 1.0×10^{-6}.

As is obvious, these numbers fall near the Commission-determined 1.0×10^{-6} threshold for determination of whether this accident is a "credible accident." If our analysis ended here, we would have considerable discomfort finding that this is indeed not a credible event. This discomfort is exacerbated by the fact that the data is limited and may have material uncertainties, and by questions regarding how it should be specifically interpreted for use in the analysis at issue here. However, we gain substantial comfort from the fact that there four aspects to this analysis wherein large conservatisms are built in.

First, all aircraft impacts are assumed to be completely radial. While no evidence or computations were presented to this Board regarding either the relative probability of a non-radial impact versus a radial impact or the consequences of a non-radial impact (a glancing blow), we find that there is reason to believe that a non-radial impact will impart less momentum to the cask, cause less damage to the cask impacted, and therefore cause less damage to the MPC. Furthermore, there is no reason whatsoever to believe that all impacts would be radial,[192] and in fact, we find, based upon simple geometric considerations, that the probability of a purely radial impact is significantly less than the probability of a non-radial impact. In fact this view is borne out by the testimony of witnesses Cornell and Thorne when asked.[193] Therefore, while we are unable to precisely quantify this effect, we find that a material conservatism (which could amount to as much as a factor of five) is introduced by this assumption.[194]

Second, the parties have assumed that any incoming aircraft which hits a "skid area" in front of the cask storage area will bounce off that area without deformation or damage to the aircraft, and without slowing down at all, and impact the cask as if it had done so directly. This assumption has the effect of increasing the effective area for the cask storage area (and therefore the probability of the accident) by approximately 15 percent.[195] There is uncontroverted evidence in the record that an F-16 is so fragile that attempts to land it on the desert would cause the craft to break up,[196] and therefore we find that there is no reason to

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[192] See Tr. at 19049-50 (Cornell), 18967-69 (Thorne).

[193] See Tr. at 19049-50 (Cornell), 18967-69 (Thorne).

[194] A simplistic and therefore obviously crude estimate by Dr Cornell would lead to a conservatism of a factor of five. See Tr. at 19050-51 (Cornell).

[195] See Tr. at 19019-21 (Thorne).

[196] See Tr. at 17787 (Fly noting that the F-16 flight manual instructs a pilot to land only on prepared surfaces), 18550-52 (Horstman describing how F-16's can only land on prepared surfaces because they are "fragile").

believe that an F-16 impacting this “skid area” would behave as assumed. In fact, we find it much more likely that: (a) such an impact on the skid area would do significant damage to the incoming F-16, causing it to impact the cask in a very different configuration than that assumed in the purely radial impacts assumed in the computations, probably with material portions broken off; (b) such an impact on the skid area would cause material amounts of the incoming aircraft’s momentum and energy to be transferred to the ground, making the resulting impact on the cask less damaging than a direct hit; and (c) it is unlikely that after such an impact on the ground the aircraft would rise off the skid area and impact the cask near the top at an angle of XXXXXXXXXXXXXXXXX or less (just given the geometry). Therefore, we find that the impact area (and therefore the probability of an accident of this type) has been unrealistically and conservatively overestimated. While we are unable to quantify this conservatism, it is clearly a material amount, in the range of 15 percent conservatism (based upon the approximately 15 percent increase in impact area which was assumed).

Third, while in our prior hearings we refused to credit the Applicant’s claim that there was a near certainty that a pilot would make the effort to avoid a crash into the facility, there was some evidence that pilots do make such efforts.[197] Thus, while we previously determined we could not assign a factor of 95 percent (i.e., a reduction in impact probability of 0.95) to the efforts of a pilot in redirecting the crashing plane away from the facility, we find that some

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[197] During the last hearing, the Applicant sought to introduce the Pilot Avoidance, or “R,” factor to reflect the Applicant’s belief that, when possible, Air Force pilots would almost always attempt to avoid striking the facility during an impeding crash. See LBP-03-04, 57 NRC at 90. To support its claim, the Applicant cited the F-16 flight manual which instructs pilots to avoid “populated areas” before ejecting if time permits. Id. at 96 n. 34. While the Board agreed that pilots would make a good faith effort to follow the F-16 manual, and noted that there were heroic instances where pilots sacrificed their own lives to save the lives of people on the ground, the Board ultimately concluded that the Applicant simply did not have enough evidence to establish that, with near certainty it claims, in an emergency situation pilots would send their crashing planes away from the Private Fuel Storage Facility. See id. at 99.

material reduction could be assigned to such efforts. Therefore, the earlier decision -- which gave no credit for such effort -- introduces another material conservatism in the computations.

Fourth, we note that the computations which have been performed and presented to us all represent events which have been analyzed and which do not cause radiation release. Many other scenarios exist which are above the bounding case -- and these have not been analyzed, and therefore may or may not cause such a release. For example, the Applicant has submitted some computations indicating that a purely radial impact at XXXXXX (which is above the bounding case) does not cause the MPC to fail. Therefore, we find that there is also some conservatism contained in the selection of the particular bounding case which has been considered.

Furthermore, in light of the foregoing analyses and the evidence presented by the Applicant and the Staff, we find that the aircraft crash risk presented by the Canister Transfer Building is *de minimus*.

The end result is that we adopt the Applicant's prediction for probability of release -- a result which was supported by the Staff's analysis -- and find that the probability of a radiation release from an F-16 accident is below the one-in-a-million per year threshold. In reaching that result -- which our dissenting colleague is unwilling to reach because of his concern that the result is too fraught with uncertain judgments, and too close to the pass/fail mark -- we think, as we discuss more specifically below, that our colleague has given inappropriate consideration to the underlying technical merits. We also believe he has not adequately weighed the fact that the foregoing materially conservative assumptions were incorporated into the analyses, each of which caused the computed probability of radiation release from a crash to be higher than would have been computed by a realistic estimate, and leading to the logical conclusion that the probability computed by the Applicant (and agreed by the Staff) is likely to materially overestimate the probability (perhaps by an order of magnitude).

Thus, even though we find the computed probability of an MPC breach to be only slightly less than one in a million (the closeness to that threshold being a principal reason for our dissenting colleague's discomfort), a number of qualitative factors exist that assure us that the probability found by the Applicant and supported by the Staff is indeed an upper bound, and that efforts to more closely model reality would make it lower. We therefore believe that a more refined analysis would result in a lower (and perhaps materially lower) probability of release, and on that basis do not share our dissenting colleague's view that the closeness of the computed probability to the threshold is disqualifying to the Applicant's proposal.

In resolving this phase of the case in the Applicant's favor, we have given careful consideration to the discomfort we understand that our colleague Judge Lam has with several aspects of the technical information before us. We believe that, although the concerns he expresses might be theoretically valid in other contexts, the facts and opinions in the record make it clear that, properly considered, the matters he has raised have no application here.

First, we find that the theory advanced by a key State witness and emphasized in the dissent -- that one should apply a tool (the ductility ratio), which is regularly used to assure that structures are designed conservatively, to determine when a non-structural element will actually fail -- was entirely discredited by the physical facts and expert testimony before us (as was the State's belated (and incorrect) suggestion that the ASME Code advises something similar). A structural design criterion, good as it may be for that purpose, does not answer the different question being asked here, and the State simply misapprehended the portion of the ASME Code to which it made reference.

It may be that underlying our colleague's concerns regarding the integrity of the Overpack is the possibility, about which he asked several questions during the hearing, that a crashing aircraft might penetrate a cask and push overpack materials into the canister inside. As we view the record, all the expert testimony and the computer simulations confirmed that -- because the cask's ring of concrete is confined by inner and outer steel shells -- if an aircraft

were to hit the outer shell, the pressure and loads would be transmitted circumferentially (at the speed of sound) around the overpack concrete, spreading and reducing the localized loads on the inner liner and avoiding the result our colleague inquired about.

Furthermore, whereas the dissent focuses upon the structural characteristics of the overpack and argues that a ductility ratio should be used to assess its integrity and ability to resist the impact, the record clearly indicates two things: first, the carbon steel rings confining the concrete can withstand a great deal more strain before failure than the approximately 2 percent which the State's expert (and the dissent) would have us use (the evidence indicates that failure strain is on the order of 50 percent or more for such carbon steels); and secondly, although of materially lesser import, the overpack is not serving as a structural member and therefore would, in any event, not be the type of component to which a ductility ratio type test should be applied.

Second, the dissent is concerned about the uncertainty associated with the fact that the Air Force accident reports do not supply all the data about speed and angle of impact that we would like to have had. The dissent is correct that the set of crashes for which complete data is available is relatively small. But all the experts agree that, through standard, commonly-used statistical techniques, extrapolations can be made (applying correlations appropriately derived from the crashes with complete data) from the valid data that are available for the other crashes, so as to allow expansion of the data set; this is recognized as an accurate way to take advantage of the additional information available from those other crashes. Indeed, the State's own expert did not dispute that principle, and this use of additional information was validated by the fact that the regression analysis achieved a correlation coefficient in excess of 90 percent (an unusually strong correlation, which the dissent dismisses as "good but not perfect").

Third, the dissent points to the expert disagreement about how to fit a curve to, and thus learn more from, the very few high speed crashes reflected in the data set, especially because

the State's statistical expert demonstrated that using a particular form of step function to fit that data would lead to a much higher probability of crash at high speed. But there are two ways to apply a step function, and if the State's expert had used the alternative method to fit the data (i.e., if he had the steps start, rather than end, at a data point, a fit which we believe is a better representation of the data), the result would have been a significantly lower (rather than higher) probability of breaching impact than that obtained by the Applicant and the Staff. Even more importantly, because phenomena at the macroscopic level are not "quantized," we do not agree that a step function was appropriate at all -- the proper way to "fit" data on real world events is to draw a curve through them, which is how the Applicant's and the Staff's experts proceeded.

In sum, we think no concern expressed by our dissenting colleague has the technical support in the record that would transform his theories into a finding of a higher radiation release probability for the situation at issue here. In addition, the dissent does not appear to give any weight to the large conservatisms which are built into the analyses -- conservatisms which indicate to us that these computations overestimate the probability of an MPC rupture by a factor of five or even more. In this regard, in setting the standard for this case, the Commission made clear the legitimacy of evaluating and weighing conservatisms whose impact can be reasonably estimated, and in fact indicated that in such circumstances the threshold probability for a credible accident might be even further increased. See CLI-01-22, 54 NRC at 260 (citing the steps a Licensing Board took in that regard in Consumers Power Co. (Big Rock Point Plant), LBP-84-32, 20 NRC 601, 639-52 (1984)).

For the foregoing reasons, we remain unpersuaded by our colleague's concerns.

In light of all of these conservatisms in the computations and methodology, and based upon the foregoing review, we find that the accidents at issue are not credible and therefore need not be included in the design basis for this facility.

III. CONCLUSIONS OF LAW AND CONCLUSION OF THE PROCEEDING

This Licensing Board has considered all of the material presented by the parties on Contention Utah K ("credible accidents") . Based upon our review of the evidentiary record relative to this contention and of the two sets (initial and reply) of proposed findings of fact and conclusions of law submitted by the parties, the Board has decided the matters in controversy concerning this contention in the fashion delineated in the views set forth above -- which we believe are supported by a preponderance of the reliable, material and probative evidence in the record, and are in accord with applicable laws and regulations.

This Initial Decision does not attempt to address explicitly all aspects of the parties' proposed findings. To the extent a particular proposal was not so addressed, it is either because we have determined that to do so was unnecessary to our decision, or because our reasoning addresses it implicitly.

In accordance with the views previously expressed herein, the Board reaches the following ultimate legal conclusions in favor of the Applicant Private Fuel Storage, LLC (and the NRC Staff):

1. The evidence establishes that the probability is less than one-in-a-million per year that there will be an accidental crash into the PFS site by an F-16 from Hill Air Force Base that has the consequence of breaching a multi-purpose-canister containing spent nuclear fuel and thereby causing a radiological release.

2. Because of that low probability, an accidentally crashing F-16 impacting a cask while traveling beyond the structurally-related "bounding speed and angle" utilized to determine that probability is not a "credible accident" as defined in agency regulations.

3. The proposed PFS facility need not, therefore, be designed to withstand such an accident and no inquiry need be made into the radiological consequences of such an accident.

Accordingly, for the reasons set forth herein, we determine that the Applicant has met its burden with respect to Contention Utah K and we rule in its favor thereon: Contention Utah K is RESOLVED on the merits in favor of the Applicant Private Fuel Storage, LLC (and the NRC Staff) and against the intervenor State of Utah.

All the Intervenors' Contentions admitted into the proceeding have now been resolved, whether by voluntary withdrawal, summary disposition, negotiated settlement, Board decision following an evidentiary hearing, or other means. There has been no ultimate resolution of an admitted Contention of a nature that would preclude issuance of the license requested by the Applicant and, with the conclusion of substantive Licensing Board proceedings, the question of whether to issue a license is now properly before the Commission for determination pursuant to 10 C.F.R. § 2.764(c). See also LBP-05-05, 61 NRC at ___ (slip opinion at 23-25) (February 24, 2005).

We close with three additional thoughts (in which Judge Lam joins):

A. Scope of Decision. In its recent decision on the length of the required Yucca Mountain isolation standard, the United States Court of Appeals for the D.C. Circuit spoke eloquently about the magnitude and importance of the national debate about how to address the presence at reactor sites of spent nuclear fuel. See Nuclear Energy Institute v. EPA, 373 F.3d 1251, 1257, 1258 (2004):

> Having the capacity to outlast human civilization as we know it and the potential to devastate public health and the environment, nuclear waste has vexed scientists, Congress, and regulatory agencies for the last half-century. After rejecting disposal options ranging from burying nuclear waste in polar ice caps to rocketing it to the sun, the scientific consensus has settled on deep geologic burial as the safest way to isolate this toxic material in perpetuity. Following years of legislative wrangling and agency deliberation, the political consensus has now selected Yucca Mountain, Nevada as the nation's nuclear waste disposal site.
>
> * * * * * *
>
> Radioactive waste and its harmful consequences persist for time spans seemingly beyond human comprehension. . . . As of 2003, nuclear reactors in the United States had generated approximately 49,000 metric tons of spent nuclear fuel. Most of this waste is currently stored at reactor sites across the country. (Citations omitted).

In issuing today's decision, we must stress that our rulings do not purport to address the questions raised by the debate to which the D.C. Circuit referred. Put another way, we do not sit, and it is not our role, to determine the optimum method by which the Nation should manage spent nuclear fuel.

Rather, what is before us is a specific proposal by the Applicant for making an away-from-reactor temporary spent fuel storage facility available for use by the nuclear utility industry. Our role has been only to pass judgment on the series of safety and environmental challenges to that proposal -- not to determine the wisest course of action for the country in terms of what should be done with spent nuclear fuel in either the short or the long term. On that score, the Commission has already indicated herein (CLI-04-04, 59 NRC at 40) that a matter like that borders on being a "political" question (in the sense, not of partisan party politics, but of policy choices, about competing societal values, that are for our elected and appointed representatives to make) -- and, as such, is a question that the Commission "do[es] not believe that NEPA charges . . . the Board, in its hearing process, with answering . . . ."

The resolution of that political question must also factor in how spent fuel can be best protected from deliberate (e.g., terrorist) attacks. Especially to the extent that such anti-terrorism factors are concerned, that debate is even more expressly outside our jurisdiction, being reserved to the Commission for consideration outside the adjudicatory process (see p. A-8, n.33, above).

In short, all determinations on overarching matters like those are for others to make. Debates on such matters will have to take place in forums other than ours.

B. Fairness to Parties. In its decision a few months ago upholding a district court's rejection, on preemption grounds, of a series of laws enacted by the Utah legislature and intended to block this project, the United States Court of Appeals for the Tenth Circuit expressed the hope that the State would receive fair treatment in the federal nuclear regulatory process that the Court recognized as paramount:

> [w]e also note that many of the concerns that Utah has attempted to address through the challenged statutes have been considered in the extensive regulatory proceedings before the NRC . . . . We are hopeful that Utah's concerns -- and those of any state facing this issue in the future -- will receive fair and full consideration there.

Skull Valley Band of Goshute Indians v. Nielson, 376 F.3d 1223, 1254 (2004).

We suppose that, after Commission review of our decision today, the losing party will appeal, and the 10th Circuit (or its counterpart, the D.C. Circuit) will have the opportunity to determine whether the hope expressed above was realized. The Court will be able to measure our decision against the underlying record that the parties compiled and that our rulings and our questions shaped.

Whether the agency's decision, and the manner in which the record was shaped, is ultimately upheld or not, we would expect the reviewing Court to come to the conclusion that the State, and the other parties, were, to the best of our ability, treated fairly, as the 10th Circuit had hoped. According them that fundamental right has been a paramount concern of ours. See Tr. at 15208-10, 19701-02; see also United States v. Steel Tank Barge H 1651, 272 F. Supp. 658, 659 n. 1 (E.D. La. 1967), referring to John M. Kelley, Audi Alteram Partem, 9 Natural Law Forum 103 (1964), authorities which we also cited three years ago. See LBP-02-08, 55 NRC 171, 201 n.60 (2002).

C. Consideration of Settlement. This proceeding has been hard and long fought, by parties fully committed to the justice of their cause. The Applicant and the State have along the way, however, settled several varied matters (e.g., those relating to (1) bird habitat [before the first aircraft trial, see Joint Motion to Dismiss Contention Utah DD -- Ecology and Species (Mar. 15, 2002); Prehearing Memorandum: Summary and Order (Mar. 22, 2002), at 5]; (2) sewage disposal [during the first aircraft trial, see App-4, below, and Joint Motion to Dismiss Contention O - Hydrology (June 18, 2002)]; and (3) cask design [after the first aircraft trial, see App-7, n.12, below]). Those settlements were built essentially on the principle that, if the license application were to be approved, a more safe or a more benign facility was in the interest of all concerned.

While the evidence on the major safety issues remained to be considered, however, there appeared to be no possibility of settling the overall proceeding. Now that all the evidence has been taken and all our decisions have been rendered, the likely outcomes are easier to see. The Applicant is in position to obtain its license (see p. C-2, above) and to hold on to it unless the State is successful, at the Commission level or in the federal courts, in overturning -- on either procedural or substantive grounds -- determinations resulting from the past seven-plus years' work.

Put another way, with aircraft crash impact probabilities now ascertained, each party can more readily assess the likelihood that it will achieve its long-term objectives. The Applicant seems to have qualified to receive its license in the short-term, but could lose it in the long-term. The State will have to count on demonstrating to the Commission or the federal courts error in some important part of the proceeding to block the license permanently.

Commission policy strongly favors settlements, and settlements sometimes are possible in unlikely circumstances. See generally CFC Logistics (Materials License), LBP-05-01, 61 NRC ___ (Jan. 11, 2005) (in which both members of today's majority were involved in the achievement of a difficult settlement, albeit one that involved a much less consequential matter). The accidental aircraft crash issue was the most difficult and most closely contested one in this entire proceeding. The outcome is a close one, as evidenced by our rationale and by our split vote. Close cases are prime candidates for settlement.

The parties may thus want to consider whether an overall resolution might be obtained through, for example, (1) the Applicant agreeing to further enhance the safety of the facility against potential aircraft crashes, such as by the construction of a berm (see Tr. at 15580-81) or of a pole-and-cable system (or a combination thereof) that would protect the casks from aircraft approaching the site in horizontal flight on the predominant azimuthal flight path; in return for (2) the State's dropping all appeals and accepting the existence of the facility as so modified. Such a settlement would truly have come about as a direct result of the State's

efforts to protect the safety of its citizens through the hearing process, and would in fact be in furtherance of that end, as well as of the Applicant's interest in further protecting its facility from accidental -- or appellate -- harm.

Absent a further Commission directive, the Board's substantive role in the case is complete (the Farrar-chaired Board does intend later to work with the parties administratively to prepare a *Redacted Version* of this decision, and the Bollwerk-chaired Board is carrying out a similar task related to the proprietary aspects of the financial qualifications issue). For the final time, then, we thank the parties for their professional, high quality presentations and participation, while also commending to their attention our thoughts about possible settlement.

Pursuant to 10 C.F.R. § 2.760(a), this Final Partial Initial Decision will constitute the FINAL ACTION of the Commission within forty (40) days of this date unless a Petition for Review is filed in accordance with 10 C.F.R. § 2.786(b), or the Commission directs otherwise.

Within fifteen (15) days after service of this Final Partial Initial Decision (which shall be considered to have been served by regular mail for the purpose of calculating that date), any party may file a PETITION FOR REVIEW with the Commission on the grounds specified in 10 C.F.R. § 2.786(b)(4). Any such Petition for Review should also cover any interlocutory rulings of ours that were not previously appealable either by NRC Rule or by Commission Order. The filing of a Petition for Review is mandatory in order for a party to have exhausted its administrative remedies before seeking judicial review. 10 C.F.R. § 2.786(b)(1).

Within ten (10) days after service of a petition for review, any party to the proceeding may file an ANSWER supporting or opposing Commission review. 10 C.F.R. § 2.786(b)(3).

The petition for review and any answers shall conform to the requirements of 10 C.F.R. § 2.786(b)(2)-(3).

It is so ORDERED.

THE ATOMIC SAFETY
AND LICENSING BOARD

[original signed by]
Michael C. Farrar, Chairman
ADMINISTRATIVE JUDGE

Peter S. Lam *
ADMINISTRATIVE JUDGE

[original signed by]
Paul B. Abramson
ADMINISTRATIVE JUDGE

* As indicated at the outset, Judge Lam dissents from the result reached in the foregoing Initial Decision, and is therefore not signing it. His signed dissent follows, on pages D-1 to D-7.

Rockville, Maryland
February 24, 2005

Copies of the *Public Version* of this Initial Decision were sent this date by Internet e-mail transmission to counsel for: (1) Applicant PFS; (2) Intervenors Southern Utah Wilderness Alliance, Skull Valley Band of Goshute Indians, OGD, Confederated Tribes of the Goshute Reservation, and the State of Utah; and (3) the NRC Staff.

So that all parties receive it at approximately the same time, hard copies of the full *Safeguards Version* are being sent by overnight delivery to the State of Utah and to the Applicant PFS, and will be hand delivered tomorrow morning at 10:00 AM EST to the NRC Staff.

Opinion of Judge Lam, Dissenting

I. Introduction

I dissent from the majority opinion for the basic reason that the proposed PFS facility has not been demonstrated to meet an established safety standard for accidental aircraft crash hazards. This safety standard, which was established in an earlier Board decision[1] and subsequently affirmed by the Commission,[2] requires that the PFS facility be designed to withstand aircraft crashes if the annual probability of such crashes exceeds one in one million (1×10^{-6} per year). The Board previously ruled in a partial initial decision[3] that the proposed PFS facility did not meet the 10^{-6} per year safety standard, and accordingly the Board did not approve the PFS license application at that time.

In this current proceeding, the Applicant has performed an extensive probability analysis and a structural analysis to rehabilitate its license application. As explained below, the Applicant's probability and structural analyses both suffer from major uncertainties. These uncertainties fundamentally undermine the validity of the analyses. Accordingly, I would hold that the Applicant has not met its burden of demonstrating that it has satisfied the 10^{-6} per year safety standard.

II. Discussion

A. Uncertainties in the Applicant's Probability Analysis

Three inter-related issues contribute significantly to the uncertainties in the Applicant's probability analysis: (1) the scarcity of F-16 crash data; (2) the quality of the F-16 crash data, as expanded by regression analysis; and (3) the sensitivity of the complementary cumulative

[1] LBP-01-19, 53 NRC 416 (2001).

[2] CLI-01-22, 54 NRC 255 (2001).

[3] LBP-03-04, 57 NRC 69 (2003).

distribution function (CCDF) to different fitting methods, and its large impact on the final calculated crash probability.

Issue 1: Scarcity of Documented F-16 Crash Data

First, there is no dispute by the parties that the data on F-16 crashes in general, and on crash impact speed and angle in particular, are sparse. Only 57 F-16 accident reports were deemed suitable for analysis by the Applicant, and only 15 reports have documented impact speed. Even if Utah's challenges to the suitability of some of these reports were entirely disregarded, these reports collectively represent a small sample.

The uncertainties inherent in using a small data set were explored by the Board in this proceeding. The Board requested that the Applicant perform its analysis using only documented crash data from the 15 reports that contain documented impact speed to assess how sensitive the results might be to such a small data set. The Applicant's results[4] indicate that using such a small set of data would imply a crash probability exceeding the 10^{-6} per year safety standard, but that the standard errors of the estimate would be unreliably large. This of course is no surprise, as it only confirms the obvious: the use of a small data set leads to large uncertainties.

Issue 2: Quality of Expanded F-16 Crash Data

The scarcity of data, the Applicant asserts, necessitates the expansion of the small data set of documented impact speeds to a larger set of estimated impact speeds by using regression analysis. The uncertainties inherent in using a small data set are now compounded by the uncertainties introduced by the regression analysis. Note that the correlation coefficients in the Applicant's regression analysis are above 0.9, but not quite 1.0, indicating there is a good, but not perfect, fit of data. This implies that additional uncertainties are now being introduced by the regression analysis. The Applicant advocates the theory that the expanded

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[4] See State Exh. 278, Summary Table for Board's Requested Calculation, by PFS expert Dr. Cornell, August 20, 2004. See also Tr. 18078-102 (Cornell explaining exhibit).

set is as good as the original set, while Utah argues that the expanded set may not adequately represent the actual F-16 crash parameters. The truth probably lies somewhere between these two opposing positions.

The uncertainties inherent in the use of a small set of F-16 crash data, compounded by additional uncertainties introduced by regression analysis, must not be ignored for two important reasons. First, the Applicant's calculated crash probability (0.74×10^{-6} per year), even if assumed to be accurate and reliable (an assumption Utah vigorously challenges), leaves scant margin for error in meeting the 10^{-6} per year safety standard. Second, the Applicant's calculated crash probability is sensitive to small uncertainties introduced by how crash data is manipulated (see discussion of the CCDF curve below).

Issue 3: Sensitivity of CCDF Curve to Fitting

The uncertainty raised by the third issue, namely how different methods of fitting the CCDF curve in the region of high impact speeds affect the final calculated crash probability, is also critical. Utah's expert Dr. Thorne, in State Exhibit 285,[5] indicates that by using actual discrete values of the CCDF for three particular impact speeds higher than the Applicant's threshold value, the annual probability of an F-16 crash breaching a spent fuel storage cask is 0.506×10^{-6} per year. This represents a significant increase from the Applicant's value of 0.375×10^{-6} per year, which is obtained by fitting the CCDF curve into a smooth curve between the aforementioned impact speeds.[6] This increase alone would bring the accidental F-16 crash probability to slightly above 1×10^{-6} per year, hence failing the 10^{-6} per year safety standard. This observation of CCDF sensitivity is important because it demonstrates quantitatively that the annual probability outcome is sensitive to a seemingly small uncertainty introduced by how crash data is manipulated.

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[5] State Exh. 285, Additional Probability Analyses, September 13, 2004.

[6] See Tr. at 18869-83 (Thorne explaining exhibit).

B. Uncertainties in the Applicant's Structural Analysis

A singularly important but unresolved dispute with respect to the Applicant's structural analysis is the Applicant's declination to adopt the DOE ductility ratio standard[7] as the failure criterion for the spent fuel storage cask. The DOE ductility ratio standard was developed by a group of experts, assembled by the Department of Energy, to protect facilities containing radioactive or chemical materials from the hazards of an accidental aircraft crash. Experts from the Defense Nuclear Agency, Federal Aviation Administration, and Environmental Protection Agency participated in that development process, with an NRC expert having observer status.

The evidence provided by Utah persuasively shows that the concrete overpack of the spent fuel storage cask is exactly the type of structure (concrete structure with carbon steel shells) to which the DOE ductility ratio should be applied as a governing failure criterion. When, as a result of an F-16 crash, the strain in the carbon steel shells of the concrete overpack reaches the failure strain set by the DOE ductility ratio standard, the overpack should be considered to have failed in performing its intended function. All parties' analyses in the evidentiary record show that the strain in the overpack's carbon steel shells significantly exceeds the DOE ductility ratio failure strain. Therefore the overpack is expected to fail in an F-16 crash scenario.

How this overpack failure would occur under the DOE ductility ratio standard, and how it would subsequently impact the stainless steel multi-purpose canister, has not been identified in this proceeding, despite numerous inquiries by Board members. This lack of clarity about how the overpack fails under the DOE ductility ratio standard is not a valid basis for asserting that the overpack would not fail. Nor is it a valid basis for asserting that the DOE ductility ratio standard does not apply to the overpack.

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[7] See State Exh. 254, United States Department of Energy Standard (DOE-STD-3014-96) Accident Analysis For Aircraft Crash into Hazardous Facilities (Oct.1996).

The caution urged by Utah's expert Dr. Sozen in advocating the adoption of the DOE ductility ratio standard for both the carbon steel shells of the overpack and the stainless steel canister should be heeded. As Dr. Sozen testified in this proceeding,[8] there are numerous uncertainties associated with how a structure would fail under aircraft crash impact. These uncertainties include: uncertain loading; the actual shape of the stress/strain curve; presence of residual stress; large strain gradients; presence of welds; potential fabrication and installation errors; and high strain rates. To appropriately deal with these uncertainties, the failure strain should be set as close as reasonable to the yield strain, namely to stay close to the elastic range. This rationale is the underlying premise of the DOE ductility ratio standard. Its adoption in this proceeding as the governing failure criterion for the concrete overpack, perhaps even for the stainless steel multi-purpose canister as urged by Utah, would have been prudent.[9]

The use of the DOE ductility ratio standard is also bolstered by the latest theory advanced by Utah regarding how Appendix F to section III of the ASME code should be applied to determine the failure strain of the multi-purpose canister.[10] Here, Utah argues persuasively that using material properties for stainless steel provided by the ASME code, taking into account neither strain hardening nor transformation of engineering strain to true strain, would predict a failure strain of less than 10 percent. This 10 percent value is significantly less (by a

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[8] See Tr. at 16243-44 (Sozen).

[9] I do not join in the majority's belief that the DOE ductility ratio standard is merely a design tool, and that a significant violation of that standard will pose no threat to the concrete overpack or the stainless steel canister. However, even if the DOE ductility ratio failure strain were merely a design failure strain, prudent safety practice (and the position advocated by Utah) would still require preventing the strain in the overpack and the canister from greatly exceeding the ductility ratio failure strain. To greatly exceed a design failure strain is to erode whatever conservatism is incorporated in the design.

[10] See State of Utah's Reply Findings of Fact (Nov. 19, 2004) at 15-25; State of Utah's Response to Board Order Directing Clarification of Record (Dec. 8, 2004).

factor of about 4) than the value the Applicant used in its analysis for failure strain in the stainless steel multi-purpose canister.

III. Conclusion

Simply put, in contrast to the demonstrated robust safety margin against design seismic events found in our earlier decision LBP-03-08,[11] the proposed PFS facility does not currently have a demonstrated adequate safety margin against accidental aircraft crashes. Even if the Applicant were to overcome all of the aforementioned uncertainties in its analyses, the proffered probability of 0.74×10^{-6} per year of aircraft crashes leading to unacceptable consequences has a margin of only 26 percent when measured against the safety standard of 1×10^{-6} per year. This 26 percent margin rapidly disappears when one or more of the aforementioned uncertainties are considered. For example, if either the documented impact speeds alone were used, or the DOE ductility ratio standard were adopted as the concrete overpack and multi-purpose canister failure criterion, the proposed PFS facility would immediately fail the 10^{-6} per year safety standard.

This lack of adequate safety margin is a direct manifestation of the fundamentally difficult situation of the proposed PFS site: 4,000 spent fuel storage casks sitting in the flight corridor of some 7,000 F-16 flights a year. The venerable four-factor aircraft crash formula in NUREG-0800,[12] which has been used for years to steer reactor license applicants away from difficult sites facing significant aircraft hazards, has already indicated once[13] that the proposed PFS site fails to meet the safety standard of 10^{-6} per year.

[11] 57 NRC 293 (2003).

[12] NUREG-0800, Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants (Rev. 2) (July 1981).

[13] See LBP-03-04, 57 NRC 69 (2003).

The Applicant's current analyses, which are fundamentally undermined by large inherent uncertainties and narrow safety margins, should not be relied upon to demonstrate the safety of the proposed site. More needs to be done. The Applicant should demonstrate that a breached spent fuel storage cask would not result in a site-boundary radioactive dose exceeding regulatory limits, or should implement other remedies such as the installation of physical barriers. Such a decisive demonstration, or the implementation of genuine remedies, would ensure the adequate protection of public health and safety.

_____[original signed by]___
Peter S. Lam
Administrative Judge

APPENDIX TO LICENSING BOARD DECISION

OF FEBRUARY 24, 2005

IN PRIVATE FUEL STORAGE PROCEEDING

In this Appendix, all three Board members provide additional information about both the earliest and the latest stages of the case.

In Part A, we set out the procedural history of those aspects of the proceeding not related to the one remaining Contention, and cover as well certain principles that govern our proceedings. This should be of assistance to those readers who have not previously followed the PFS proceeding.

In Part B, we explain why it has been nearly two years since our decision on the first phase of the hearing on that Contention, and detail what has been accomplished during that period. In this fashion, we have completed the report that the Commission sought from us if the proceeding took longer to conclude than it expected.

A. Early History.

1. The PFS Application. The PFS consortium of nuclear-powered electric generating companies filed its application with the NRC on June 20, 1997, seeking a temporary solution to the industry's perceived need to take action with respect to the growing quantities of spent nuclear fuel accumulating at reactor sites. The uncertainty and delays being generated by the Department of Energy's inability to fulfill its mandate to take that spent fuel from the utilities (such as by moving it to the proposed permanent underground repository at Yucca Mountain in Nevada) led PFS to seek NRC approval to build a facility for temporary above-ground storage of that spent fuel. The understanding -- which we discussed in another decision issued earlier today (see LBP-05-05, above, 61 NRC at ___) (slip op. at 1-2) -- is that the PFS facility would

REDACTED VERSION FOR PUBLICATION

store the spent fuel rods, currently housed at nuclear reactor sites around the country, until they could be moved directly to the permanent repository.[1]

The Applicant seeks to store the spent fuel on the Reservation of the Skull Valley Band of Goshute Indians, within the 99-acre secured portion of a larger site being leased from the Band for that purpose. While the Reservation is within the boundaries of the State of Utah, the special sovereign status of recognized Indian Tribes essentially protects the proposed activity from being subject to the State's ordinary regulatory jurisdiction. As mentioned earlier, then, one way the State has expressed its concerns over, and objections to, the proposal was by bringing its safety and environmental contentions to us for resolution.

The PFS application was reviewed by the NRC Staff. That process consumed over three years, during which time the Staff made any number of requests for additional information, and the Applicant revised its application nineteen times. The NRC Staff approved the application on September 29, 2000.[2]

2. The Hearing Opportunity. Early on during the Staff review of the application, the NRC published in the *Federal Register* the July 1997 notice of hearing. The notice stated that anyone opposed to the issuance of the license could request a hearing before an Atomic Safety and Licensing Board.

The Licensing Board is an independent adjudicatory branch of the NRC, whose judges are appointed,[3] and whose decisions are reviewed, by the Commissioners who head the NRC.[4]

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[1] At this writing, it appears that DOE's application to the NRC for approval of the Yucca Mountain facility will not be filed any earlier than the end of 2005.

[2] LBP-03-04, 57 NRC at 82. By the time of our original 2002 hearing on the State's "credible accidents" contention, the application had been amended four more times.

[3] Although the Commissioners appoint judges to the overall Licensing Board Panel, it is generally the Panel's Chief Judge who assigns judges to particular Board proceedings.

[4] LBP-03-04, 57 NRC at 92 n. 28. Our decisions are reviewable by the Commissioners, with whom we have no interaction other than through our decisions and their formal, on the record, review thereof.

The Board's existence provides individuals and organizations who oppose any licensing action the NRC Staff proposes to take, or has taken, the opportunity to present the concerns they have to an independent, quasi-judicial forum within the agency.

As mentioned previously, several parties took that opportunity and presented some 125 issues that they wished to have adjudicated before the Board. The Board admitted those parties who it determined had demonstrated their legal "standing" to participate and who had proffered admissible contentions.

3. The Parties' Contentions. Several petitioners sought to oppose the PFS facility.[5] As mentioned above, the petitioners submitted some 125 contentions challenging the proposed facility. The number of contentions was reduced as the proceeding progressed. Many were dismissed initially on procedural grounds, such as not being filed within the proper time frame or for being outside the jurisdiction of the Board. Other issues, though appearing appropriate for consideration by the Board, were later decided on legal grounds, through "summary disposition" procedures, as they did not involve a significant factual dispute that would require evidentiary presentations. Some matters were settled. In other instances, a party that introduced a contention later withdrew it after determining that it no longer wished to litigate the issue.

[5] Along with the State of Utah, the Southern Utah Wilderness Alliance also presented several contentions, one of which went to evidentiary hearing. Other petitioners who participated to a lesser extent included the Skull Valley Band of Goshute Indians, Ohngo Gaudadeh Devia, Confederated Tribes of the Goshute Reservation, David Pete, Castle Rock Land and Livestock, Skull Valley Company, and Ensign Ranches of Utah. See LBP-98-07, 47 NRC 91, 156-57 (1998).

The several contentions that remained were the subject of full evidentiary hearings.[6] In that regard, the 45 days of evidentiary hearings conducted in 2002 on aircraft crashes, seismic standards, and environmental/wilderness values (as well as on a hydrological issue that was settled in mid-trial (see 57 NRC at 81 n. 6; p. C-4, above)) were all open to the public, with the vast majority of those sessions held in Salt Lake City.

We have commented previously on the concern, sometimes expressed by observers of our hearings, as to the NRC Staff's appearing to be too much on the side of an applicant. LBP-03-04, 57 NRC at 82, 83-84. As this case illustrates, that alignment occurs only after the Staff has conducted its lengthy review and the Applicant has responded by making changes that the Staff has insisted upon. The Staff's support of an applicant's position at the hearing does not, then, establish that the Staff has failed to carry out its duty to protect the public interest.

While the Staff's regulatory review plays an important role in the application process, and the presentation of its position based thereon is an important aspect of the hearing process, we insist upon treating the NRC Staff (with whom we have no extra-judicial organizational interaction) the same as any other party at the hearing. In particular, we subject the Staff's evidence to the same scrutiny as that of the other parties. See LBP-03-04, 57 NRC at 140 n.124 and accompanying text; see also n. 13, below.

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[6] The Bollwerk-chaired Board (see p. A-1, n.19, above) conducted an evidentiary hearing in 2000 on the merits of several contentions, including financial assurance and emergency planning. Some of that Board's partial initial decisions include: Emergency Planning, LBP-00-35, 52 NRC 364 (2000), petition for review denied, CLI-01-9, 53 NRC 232 (2001); Financial Assurance (May 27, 2003) (unpublished pending review of proprietary information); Decommissioning (May 27, 2003) (unpublished pending review of proprietary information).

In addition to hearing the aircraft crash matter, the Farrar-chaired Board took evidence and issued partial initial decisions on Geotechnical Issues, LBP-03-08, 57 NRC 293 (2003), petition for review denied, CLI-03-08, 58 NRC 11 (2003); and Rail-line Alternatives, LBP-03-30, 58 NRC 454 (2003).

B. Recent Timing

In deferring its review of our March, 2003 decision on aircraft crash probabilities, the Commission indicted its expectation that we would be able to reach a decision on the subsequent "consequences" phase by the end of that year. Today's decision comes nearly 14 months after that target.

If someone were to ask "what went wrong", the simple answer would be:

Nothing. Analysis of the progress of this case over the past two years illustrates that: (1) the Staff's regulatory review process functioned as it should; (2) the Applicant used large amounts of time to refine the justifications for its application; and (3) during the periods that the process was under the Board's control, the diligence of all parties and our case management efforts kept the adjudicatory process moving on schedule.

This proceeding was convened to determine the safety of a proposal that could result in the Nation's stockpile of spent nuclear fuel resting aboveground, at an away-from-reactor site, for a very long time.[7] The current "consequences" phase involves a complicated and significant question that was a direct outcome of the Applicant's choice of a site about which safety concerns were triggered by the overflight of 7,000 F-16s a year.[8] As the parties

[7] That period was initially thought to be 20 years. The State unsuccessfully challenged its extension to 40 years. See CLI-04-22, 60 NRC 125, 148-50 (2004). Recently, the Commission approved a 40-year extension for on-site aboveground cask storage at one reactor site (see NRC News, No. 04-156, "NRC Approves 40-Year License Renewal for Independent Spent Fuel Storage Installation at Surry Nuclear Plant" (Dec. 8, 2004)). That decision indicated a continued belief that spent fuel could be stored in dry casks for at least 100 years without significant environmental impact because the additional years do not pose any obvious "aging-type" safety issues. Our decision today, then, could conceivably lead ultimately to very lengthy storage of spent nuclear fuel in Skull Valley.

[8] In other words, the issue we decide today was brought on by the Applicant's own election to move forward with a site that could readily be seen -- with a look upwards and a look to the standard screening formula -- to be a problematic one.

proceeded with this phase, and as is not uncommon in complex proceedings like this one,[9] the NRC Staff found the Applicant's submittals wanting, and therefore pursued clarification through a number of requests for additional information (RAIs). Because of these apparent shortcomings in the Applicant's submittals, additional (iterative) work was required to get the application to a stage where the Staff could support it. Those two parties' needs for more time to "get it right" led to the periodic (temporary) suspension of the formal adjudicatory process at the Applicant's request; all agreed that no purpose would have been served by wasting time (and effort) on adjudicating an incomplete or unsupportable application.

In various procedural orders,[10] we explained each resulting alteration of the original schedule we had set out for the parties, a schedule which had initially targeted a year-end 2003

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[9] See Duke Cogema Stone & Webster (Savannah River Mixed Oxide Fuel Fabrication Facility), CLI-01-13, 53 NRC 478, 484-86 (2001) where the Commission set forth an aggressive adjudication schedule, which the Board was prepared to implement (see unpublished Memorandum and Order (setting Phase I schedule) (July 17, 2001)). The Applicant notified the Board on January 24, 2002, however, that it needed to amend its Construction Authorization Request and Environmental Report. The Applicant's changes, and the Staff's review of those changes, ultimately led to a two-year scheduling delay beyond the Board's control.

[10] See the following unpublished prehearing orders in which we dealt with scheduling:
- Scheduling Memorandum and Report (July 31, 2003);
- Scheduling Memorandum and Report (Aug. 15, 2003);
- Scheduling Order and Report (Sept. 9, 2003);
- Order Suspending Schedule (Oct. 10, 2003);
- Order Convening Conference Call (Regarding Contention Utah TT and Hearing Schedule) (Feb. 5, 2004);
- Order Summarizing Prehearing Conference Call (Regarding Contention Utah TT, Hearing Schedule, and Related Matters) (Feb. 19, 2004);
- Order Summarizing Prehearing Conference Rulings (Regarding Contention Utah TT and Hearing Schedule) (Feb. 27, 2004);
- Memorandum Concerning Scheduling (Apr. 15, 2004);
- Scheduling Order (Apr. 23, 2004);
- Memorandum of Conference Call (June 2, 2004);
- Memorandum and Order (Summarizing June 15 and July 1 Prehearing Conference Call) (July 14, 2004);
- Memorandum and Order (Summarizing July 15 Conference Call) (July 22, 2004).

decision and had set forth a roadmap for achieving that goal.[11] But all those scattered thoughts are worth recounting in one place, because together they demonstrate how additional time was necessary to enable the NRC's licensing process to follow its design course, and how this process eventually benefitted the public interest (and, as will be seen, even the interests of the Applicant, who, not untypically, indicated at every possible juncture a strong preference for agency rulings that come sooner rather than later).

1. We begin by observing that the agency's regulatory process can accommodate the evolving needs of an applicant to enhance its proposal from a safety standpoint,[12] or to develop a better information base to demonstrate its safety. As that preparatory process unfolds, however, the time consumed by an applicant's preparation cannot necessarily be attributed to the adjudicatory process or to the Board's oversight of that process. Moreover, all involved recognize that we have no supervisory power whatsoever over the Staff's performance of its regulatory review activities. See Duke Energy Corp. (Catawba Nuclear Station, Units 1 and 2), CLI-04-06, 59 NRC 62, 74 (2004) (citing, e.g., Curators of the University of Missouri, CLI-95-01, 41 NRC 71, 121 (1995)).

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[11] See June 25, 2003 transcript of Conference Call, where we built on the parties' June 19, 2003 "Joint Report on Proposed Schedule," at 9-10, to set forth a schedule (referred to in our July 31, 2003 order, above) that would have met the Commission's year-end decisional timeframe; see also the schedule that superseded it (set out on p. 6 of our Sept. 9, 2003 order, above) that, even with the slippage encountered by then -- attributable to the Applicant's delay in filing expert reports, filing more reports than expected, and need to evaluate the timing of its response to Staff RAI's -- would have led to a decision in mid-April of last year. That second schedule was itself was suspended at the Applicant's behest a month later for what proved to be a very lengthy period.

[12] For example, in the midst of the preparation for the consequences hearing, the Staff's questions led the Applicant to discover an accident-related shortcoming in an aspect of cask design. The Applicant devised a solution and amended its license application to reflect the change (its Safeguards aspects preclude our detailing it here). This change, in turn, prompted the State to file on January 9, 2004, a new contention, denominated Utah TT, challenging the change as creating a different kind of problem, this one of an operational nature. At our suggestion, the parties were able to avoid litigating the new contention by settling the underlying dispute, by way of the Applicant's agreeing to do test runs that would eliminate the operational concern. See our unpublished Orders, above, of February 19, 2004 (at 3) and February 27, 2004 (at 2). This all took some time -- but cask design and facility operations were both made safer because of it.

Accordingly, it is paramount to recognize that the schedule for the adjudicatory process is not wholly, and sometimes not even largely, within the Board's management and control. In this instance and in others, one should expect a not insignificant portion of the time to be consumed by the interactions between the applicant and the NRC Staff, as the applicant polishes the application and its supporting data to enable the staff to accept its approach and conclusions.

Here, early on the Applicant needed additional time to provide its initial round of expert reports setting forth its position on the "consequences" issue, and then actually proffered more reports than were anticipated. This, in addition to the delays in generating the reports themselves, resulted in additional time for responsive filings.

At the same time, perhaps to ensure there was no possibility of the types of shortcomings identified in the positions it advanced before us in the course of the first aircraft hearing,[13] the Staff, apparently finding the application to be falling short of what was needed for its approval, made a concerted effort to pursue additional information prior to the hearing. Thus, it presented the Applicant with a series of RAIs, the second set of which resulted in the proceeding going into abeyance for an additional period of over four months -- at the Applicant's behest -- while the Applicant developed its answers.

The course followed here demonstrates how the process sometimes works. To fulfill their respective roles, the Applicant must submit a thorough and compelling application demonstrating that it meets the regulatory requirements, and the Staff must diligently seek out thorough answers to its concerns. In such a process, it should be expected that, as was the case here, the applicant will, of necessity, expend considerable effort and consume considerable time and resources in the course of responding (and perhaps in revising its application).

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[13] See LBP-03-04, 57 NRC at 97 n.38, 109 n.66 (sensitivity analysis); 118-19 (aircraft formation analysis); 133-35 ("order of magnitude" evaluation); 133 n.97; 134 n.02 ("one-way" outlook); 135, n.105 (failure to sharpen focus); and 138 (lack of parallel action).

The extra time involved should be expected to benefit the public interest, as the Staff assures that the application satisfies the regulatory requirements. The additional information developed should as well put the Applicant in a better position to defend its proposal at the hearing, and it should allow the Staff to take a more forceful position at the hearing in support of the Applicant. In the hearing on seismic matters, for example, the Staff's support (albeit derived from a source other than RAI responses) played an important role in this Applicant's success.[14]

As it turns out, in the instant case, the extra time and effort also benefitted the Applicant -- after all, it has today obtained a favorable decision. In contrast, had the evidence in this phase of the aircraft hearing been submitted in time for us to render a late-2003 decision, the Applicant might not have had the Staff's support. And whether it did or not, the Applicant's evidence available at that time may have proved inadequate for it to carry its burden of proof.

In thus indicating the Applicant may have benefitted from the extra time it devoted to preparing the information to support its application, we hasten to add that we have no interest in whether an applicant or an intervenor prevails in any of the matters that come before us. Two years ago, we ruled against the applicant on the first aircraft crash phase; today we rule in its favor on the second phase. In both instances, we did have an interest in the record being developed in a manner that "allow[s] us to make an informed decision" (LBP-03-04, 57 NRC at 141) on the merits without regard to which party our decision favors.

2. The foregoing observations apply to the great portion of the process, taking place in the nearly two years since our probability decision, that was <u>not</u> under our control. As they illustrate, we -- like other Boards -- control only a portion of the period during which an application is under agency consideration, which sometimes has been inaccurately attributed to time consumed by the adjudicatory process. The relative amount of time consumed by the adjudicatory process, compared to the Staff's regulatory review, will in large measure depend

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[14] <u>See</u> discussion of Dr. Luk's work in LBP-03-08, 57 NRC at 352, 354-55, 357 (2003).

upon the degree to which the application, on which the hearing is to be held, comes with a thorough foundation at the outset.

In this particular instance, the part of the two-year process that was under our control was managed, we think it fair to say, in an efficient manner that sped both the hearing and our decision along, and was fair to all involved. Once the matter came back to us after being in abeyance, we set a schedule and adhered to it. This was due both to the diligence exhibited[15] and accommodations made[16] by all three parties (for which we commend counsel from the Applicant, the Staff and the State), and to our innovative management of both anticipated[17] and

[15] For all practical purposes, once the hiatus ended and a new schedule was instituted, the parties met their filing obligations in a timely fashion.

[16] For example, the parties on their own made major adjustments to their cross-country deposition schedules to accommodate the serious medical problems encountered by a key witness.

[17] For example, we required the parties to submit, during the run-up to the hearing, not only pre-filed direct testimony but pre-filed rebuttal testimony as well (a step not required by the former version of the Rules of Practice, still applicable here). Having done that, we were able to institute a practice, when a witness took the stand to adopt orally his written pre-filed direct and pre-filed rebuttal testimony, of having that witness also be asked on initial examination by his counsel to respond to any issues raised in the other parties' pre-filed rebuttal testimony. This avoided as much as possible having witnesses return to the stand on repeated occasions to provide rebuttal and other forms of responsive testimony, an approach which had seemed particularly inefficient during the earlier seismic hearings. See Telephonic Prehearing Conference of July, 15, 2004, Tr. at 15162-63. This technique worked here; whether it would work in other circumstances is an open question.

unexpected[18] matters, some of which were of a routine nature,[19] and some of which could have been confounding.[20]

In the final analysis, then, the fourteen month extension beyond the Commission's target date for completion of this stage of this case was simply attributable to the need to fulfill

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[18] We found it helpful on occasion to depart from the usual order and to construct an impromptu "debate" between the witness on the stand and a prior witness from an opposing party. In this fashion, the competing views of both could meet head-on, or those views be reconciled on the spot, rather than through seriatim appearances. This not only promoted the efficient use of time, but it enabled, to the maximum extent practicable, sensible resolution of issues.

[19] We imposed measures to simplify the hearing logistics -- avoiding wasting time on housekeeping procedural matters -- that shortened the hearing's overall length. For example, we required the parties, not only to pre-file all their exhibits for our prehearing review, as is customary, but also to pre-stamp the copies to be formally introduced. In uncomplicated cases, that step might not be necessary -- but in this proceeding that simple pre-arranged administrative measure conserved enormous amounts of hearing time compared to earlier portions of this case.

In that regard, much time was consumed during the 2002 hearings by the need to stop the proceeding, each time an exhibit was identified and offered, to allow the court reporter to stamp each of the several copies and insert on each the necessary information (party name, exhibit number, date offered, and sponsoring witness). This proved especially burdensome and inordinately time-consuming when many exhibits were submitted simultaneously. During this phase, we required the parties to stamp and mark their exhibits in advance, thus allowing our law clerk simply to take possession of the exhibits without causing any interruption of the court reporter or of the proceeding. This was especially useful upon each party's starting to present its witnesses, occasions which led to the submission of a combined total of approximately 100 exhibits.

[20] For example, it was apparent that a variety of looming scheduling conflicts would have prevented the hearing's resumption for a considerable period if it were not concluded by September 15. We thus took the precaution of convening an unusual Sunday session on September 12 to assure that we finished on time.

This concern about ending the hearing served as a book-end to how we began it. To assure that the hearing started into substantive business promptly, without losing time for housekeeping matters, we had made arrangements for the parties to set up in their conference rooms off our hearing room on Sunday, August 8, the day before the hearing began.

properly the Atomic Energy Act's demands: to carry its burden of proof, an applicant must provide information sufficient to allow the agency to pass knowledgeable judgment on whether the license being sought is consistent with the protection of the public health and safety and the environment. Much of that is done outside our control. Where the process was within our control, we can report that there was no failure in the adjudicatory process or in our supervision of that process.[21]

This completes the Appendix.

[21] We note that this decision is being issued (for all practical purposes) within the time-frame the Commission typically expects (see p. A-3, n.22, above), even though (1) the hearing was long and the issues quite complex and (2) there arose another matter, also decided today (LBP-05-05, involving a recently-filed contention) that required our attention along the way.

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

In the Matter of	)	
	)	
PRIVATE FUEL STORAGE, L.L.C.	)	Docket No. 72-22-ISFSI
	)	
(Independent Spent Fuel Storage Installation)	)	

CERTIFICATE OF SERVICE

I hereby certify that copies of the foregoing LB ORDER ISSUING REDACTED VERSION OF FINAL PARTIAL INITIAL DECISION (LBP-05-29) have been served upon the following persons by deposit in the U.S. mail, first class, or through NRC internal distribution.

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Office of the Secretary of the Commission

Dated at Rockville, Maryland,
this 28th day of October 2005